THE UNIVERSITY OF ALBERTA

STATISTICAL ESTIMATION OF THE ELASTICITIES OF DEMAND FOR NONDURABLE GOODS IN THE CANADIAN ECONOMY

by

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ABSTRACT

In this study, statistical estimates of the elasticities of demand for fourteen nondurable goods, for the period 1956 to 1965, using quarterly data are obtained. Chapter I presents the purpose of this study and its objective. Chapter II presents a brief survey of demand theory and a localized survey of empirical studies of demand. The theoretical part includes a short review of demand models as developed by Barten, Theil, Houthakker and Stone. The empirical part includes both time series and cross-section studies in the context of the Canadian economy. Chapter III presents a model and its preliminary results. This is a simple multiple regression model, with expenditures on a particular commodity group as the dependent variable and relative price and real disposable income as the explanatory variables. A distributed lag model of a Koyck type is used to test for the existence of lag in consumer response to changes in relative prices and real disposable income. It is well known that in the context of a distributed lag model, Liviatan's method yields consistent estimates regardless of the assumptions about the structure of the disturbances. This method is used in Chapter IV. A comparison of the ordinary least squares estimates and the estimates obtained through Liviatan's method reveals that ordinary least squares tend to overestimate the implied lag. In Chapter V the demand for different goods is considered as

an interrelated decision. A modified form of Zellner's efficient method of estimating "seemingly unrelated" regressions is used. A comparison of the results of this method with ordinary least squares is also given, as well as a comparison of the results of this study with the results obtained for the U.S. (by Houthakker and Taylor) and U.K. (by Stone). In Chapter VI some conclusions are presented, which include implications for policy derived from the results obtained in this study.

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CHAPTER I

INTRODUCTION

This chapter is divided into two parts. Part I explains the purpose of this study. Part II gives the objective and the plan of the thesis.

Part I

The knowledge of price and income elasticities of demand is useful for policy purposes. For example, an increase in the excise tax on a commodity will ordinarily raise the price of the commodity. Depending upon the elasticity of demand, this effect, in turn, will create varying effects on the quantities consumed. The more inelastic the demand for a product, the less the curtailment of consumption and the greater the revenue yield. The knowledge of price and income elasticities is also useful for projecting the demand for different goods and services.

Since the pioneering work of Henry Schultz, Richard Stone and Herman Wold, there have been many empirical studies of demand.[1] Hood,[2] in the conclusion of his survey, empha-

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[1] A survey of classic works in demand analysis can be found in Wm. C. Hood, "Empirical Studies of Demand", Canadian Journal of Economics and Political Science, Vol. 21, No. 3, (August, 1955), pp. 309-327.

[2] Wm. C. Hood, *op. cit.*, p. 327.

sizes the need for further research using advanced statistical techniques. As econometric methods develop it is useful to obtain estimates of price and income elasticities of demand using the more advanced methods of estimation.

For the Canadian economy, very few attempts have been made towards estimating the elasticities of demand.[1] These estimates are highly aggregative in nature and are all based on annual data. A highly disaggregative study is desirable because much of the information is lost in the process of aggregation, both over time and over commodities.

The adjustment of quantity demanded due to a price change or an income change is not instantaneous. Houthakker and Taylor[2] have demonstrated that for the U.S. economy habit formation was important in the consumption pattern and that a distributed lag model was relevant. They have emphasized the need for a study of lagged response in consumer behavior for the Canadian economy.[3] In addition there is some evidence to show that the consumption pattern in Canada is different from that of the U.S.[4]

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[1] See Chapter II for a survey of the literature.

[2] H.S. Houthakker and L.D. Taylor, Consumer Demand in the United States, 1929-70 (Harvard University Press, Cambridge, 1966).

[3] H.S. Houthakker and L.D. Taylor, op. cit., pp. 195-196.

[4] J.M. Due, "Consumption Levels in Canada and the United States, 1947-50", Canadian Journal of Economics and Political Science, Vol. 21, No. 2 (May, 1955), pp. 174-181.

So far there have been no studies at a disaggregated level which have investigated the lagged response of consumer behaviour in the Canadian economy.

Part II

The objective of this dissertation is to estimate the price and income elasticities of demand for the fourteen non durable commodity groups. Quarterly data for the period 1956-65 are used. These are farm foods, purchased foods, meals, tobacco products, alcoholic beverages, men's clothing, women's clothing, piece goods, notions, footwear, household supplies, soap and cleaning supplies, drugs and cosmetics and newspapers and magazines. Both short run and long run elasticities were obtained. Due to its simplicity a Koyck type of distributed lag model was used to estimate the extent of the lag and the long run elasticities.[1] A Koyck type model reduces to a multiple regression equation with a lagged value of the dependent variable as an explanatory variable.

In addition to the ordinary least squares there are various other methods of estimation available in the literature in the context of a distributed lag model. These are due to Koyck, Klein, Taylor and Wilson, Liviatan, Hannan,

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[1] The other well known distributed lag models are due to Solow and Almon. These have not been employed here because of complicated computation problems.

Amemiya and Fuller and Dhrymes.[1] In this study both the ordinary least squares method and Liviatan's technique are used.

The demand for food, clothing, footwear etc., are all interrelated. For this reason the consumption of different goods is viewed as an interrelated set of decisions.[2] Zellner's "Seemingly Unrelated" technique is used to estimate the system of equations.[3]

The plan of the thesis is as follows. Chapter II presents a very brief outline of the theory of demand and an exhaustive survey of empirical studies of demand conducted for the Canadian economy. The survey includes both the time series and cross section studies. Chapter III is devoted to a description of the model and presents the preliminary results obtained by applying the ordinary least squares method to about 140 multiple regression equations. The results are presented both for aggregate and per capita data. Experiments have also been conducted using the total real

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[1] The references are given in Chapter III.

[2] Criticizing the "Brooking's Model" Griliches has pointed out that the model should have considered the consumption of different goods as one interrelated set of decisions. Zvi Griliches, "The Brooking's Model Volume - A Review", The Review of Economics and Statistics, Vol. 50, (1968), p. 219.

[3] A Zellner, "An Efficient Method of Estimating seemingly unrelated Regressions and Tests for Aggregation Bias", The Journal of American Statistical Association, Vol. 57, (June, 1962), pp. 348-368.

expenditure on goods and services and the real disposable income as alternative explanatory variables. These results revealed that the lag in the consumer demand due to a price and/or an income change is significant for some commodities. For these commodities the Liviatan's technique, which gives consistent estimates in the context of a distributed lag model, is used. These results are presented in Chapter IV. The results of Zellner's "Seemingly Unrelated" technique are presented in Chapter V. Also included in this chapter is a comparison of the results of this study with the results of Stone for the U.K. economy and Houthakker and Taylor for the U.S. economy.[1] In Chapter VI conclusions of the study are presented.

In Appendix I an APL program for Zellner's "Seemingly Unrelated" technique is presented. Appendix II presents the data used in the study.

[1a] R. Stone and Others, The Measurement of Consumer's Expenditure in the United Kingdom, 1920-1938 (Cambridge University Press, Cambridge, 1954).

[b] H.S. Houthakker and L.D. Taylor, Consumer Demand in the United States, 1929-1970 (Harvard University Press, Cambridge, 1966).

CHAPTER II

SURVEY OF THE LITERATURE

The objective of this chapter is two fold. First it presents a very brief survey of demand theory. Secondly it presents a survey of the methodology and the results of several attempts that were made in estimating the demand functions for the Canadian economy. Attempts have been made using both time series and cross section data.

Part I of this chapter presents a brief survey of the demand theory. In Part II a survey of time series studies is presented. In Part III a survey of cross section estimates is presented. In Part IV a comparison of both types of estimates is presented.

Part I: Demand Theory

We assume that the consumer maximizes his utility function under a budget constraint. Let the utility function be $U = U(x_1, x_2, \ldots, x_n)$, and the budget constraint be $y = \sum p_i x_i$, where y is the total expenditure, p_i is the price of the ith commodity, and x_i is the amount of the ith commodity.

The problem is

$$\max u(x_1, x_2, \ldots, x_n)$$

subject to

$$\sum p_i x_i = y$$

where $p_1, p_2, \ldots, p_n$ and y are assumed given for the consumer.

The derivation of demand functions can be obtained by forming the Lagrangian function and differentiating it with respect to x_i and the Lagrangian multiplier. We have

$$\frac{u_1}{p_1} = \frac{u_2}{p_2} = \ldots \frac{u_n}{p_n} = \lambda$$

where $u_i = \dfrac{\partial u}{\partial x_i}$ and λ is the Lagrangian multiplier.

We can solve

$$\left.\begin{aligned} u_i &= + \lambda p_i \\ y &= \sum p_i x_i \end{aligned}\right\} \quad (i=1,2,\ldots,n)$$

these (n+1) equations for $x_1, x_2, \ldots, x_n$ and λ. Let such a solution be as follows:

$$x_i = x_i(p_1, p_2, \ldots, p_n, y)$$

$$\lambda = x(p_1, p_2, \ldots, p_n, y)$$

The equations for x_i are called demand functions.

The desirable properties of any system of demand functions are:

(1) $\sum p_i x_i = y$ (Additivity).

(2) $x_i = x_i(\xi p_1, \ldots, \xi p_n, \xi y)$ (Homogeneity).

(3) $\frac{\partial x_i}{\partial p_j} + x_j \frac{\partial x_i}{\partial y} = \frac{\partial x_j}{\partial p_i} + x_i \frac{\partial x_j}{\partial y}$ (Slutsky Condition).[1]

There are four well known formulations of systems of demand functions.[2] These are

(1) The double-log system.[3]

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[1] For proof of the Slutsky condition see J.R. Hicks, Value and Capital, second edition (The Clarendon Press, Oxford, 1946), pp. 305-310.

[2] For various types of demand systems see A.S. Goldberger, "Functional Form and Utility: A Review of Consumer Demand Theory", Workshop Paper 6703, Social Systems Research Institute, University of Wisconsin.

[3] The double-log systems refers to the logarithmic functional form. This is also known as the constant elasticity of demand model.

(2) The Theil demand system.[1]

(3) The linear expenditure system.[2]

(4) The indirect addilog system.[3]

The Theil demand system, the linear expenditure system and the indirect addilog system satisfy all the three properties stated above.[4] Unfortunately the double-log system does not satisfy any of the properties stated above.

Goldberger has pointed out that the double-log demand functions cannot be rigorously deduced from maximization of a utility function.[5] Yet it is the most widely used form in empirical studies of demand. This is partly because of the

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[1] This is also known as the Rotterdam School Demand Model. The pioneering work in the development of this system is due to Barten and Theil. A.P. Barten, "Consumer Demand Functions under Conditions of Almost Additive Preferences", Econometrica, Vol. 32 (1964), pp. 1-38 and H. Theil, Economics and Information Theory (North Holland Publishing Company, Amsterdam, 1967), Chapters 6 and 7.

[2] This system is due to Stone. See R.D. Stone, "Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand", The Economic Journal, Vol. 64 (1964), pp. 511-527.

[3] This is due to Houthakker. H.S. Houthakker, "Additive Preferences", Econometrica, Vol. 28, No. 2 (April, 1960), pp. 244-257.

[4] For a proof, see K. Yoshihara, "Demand Functions: An Application to the Japanese Expenditure Pattern", Econometrica, Vol. 37, No. 2 (April, 1969), pp. 257-274 and R.W. Parks, "Systems of Demand Equations: An Empirical Comparison of Alternative Functional Forms", Econometrica, Vol. 37, No. 4 (October, 1969), pp. 629-650.

[5] A.S. Goldberger, op. cit., p. 101.

complicated computation problems involved in obtaining the other systems of demand functions.

Houthakker defending the double logarithmic functional form comments

> Despite its well known defects, especially that of non-additivity, this function (double-log demand function) remains without serious rivals in respect of goodness of fit, ease of estimation, and immediacy of interpretation.[1]

In addition there is some empirical support for the superiority of double-log system over the indirect addilog system. H.S. Houthakker estimated the elasticities of demand for food, clothing, rent and miscellaneous goods for OEEC countries. He made use of ordinary double-log functional form and indirect addilog functional form. His results[2] are presented in the following table. These results show that ordinary double-log functional form did better than indirect addilog system in all the four categories of commodity groups.

The indirect addilog system, Stone's linear expenditure system and Theil's system have been used in empirical work for explaining the behaviour of <u>entire expenditure pattern</u> and not expenditures on selected commodity groups. One should be more concerned about the properties of the demand

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[1] H.S. Houthakker, "New Evidence on Demand Elasticities", <u>Econometrica</u>, Vol. 33, No. 2 (April, 1965), p. 278.

[2] H.S. Houthakker, "Additive Preferences", <u>Econometrcia</u>, Vol. 28, No. 2 (April, 1960), p. 254.

TABLE II.0

RESIDUAL SUM OF SQUARES IN DIFFERENT FUNCTIONAL FORMS

	Residual Sums of Squares			
Form of Equations	Food	Housing	Clothing	Misc.
Ordinary double log	16.6	53.9	233.3	32.0
Indirect addilog	28.4	87.3	287.3	34.0

Source: H.S. Houthakker, op. cit., p. 254.

functions, discussed earlier, if one is estimating the entire expenditure pattern. Barten in this context comments

> Attempts to estimate demand equations can, roughly be classified into two groups. To the first group belong those studies which concentrate on an empirically acceptable explanation of demand for individual commodities, while the overall relationships between the quantities demanded of all commodities in the budget remain in the background. The second group of studies is chiefly concerned with the allocation aspect of consumer demand and has complete systems of demand equations as its object. The overall restrictions on demand equations provided by the theory of consumers' choice play a dominant role in these studies.[1]

The above mentioned reasons provide some justification for using the double-log functional form throughout this dissertation.[2]

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[1] A.P. Barten, "Estimating Demand Equations", Econometrica, Vol. 36, No. 2 (April, 1968), p. 213.

[2] One of the objectives of this study is to investigate the significance of the lagged response in consumer behaviour. With a double-log functional form it is easy to formulate a distributed lag model whereas with other types of systems it is not.

Part II: Time Series Studies

Estimates of elasticities of demand for selected commodities or groups of commodities have been obtained by using time series data on quantities purchased, prices, real income or real expenditures. For the Canadian economy attempts were made by Henry Schultz, Alan Powell, R.A. Holmes, H.S. Houthakker and others. These studies will be reviewed in that order.

Henry Schultz[1] in his pioneering work, "The Theory and Measurement of Demand", used annual time series data for the period 1922-33 to test the integrability conditions.[2]

For the Canadian economy, no data were available on the actual consumption on sugar, tea and coffee for the period 1922-33. Therefore, Schultz treated imports of these commodities as a proxy for consumption. He used multiple regression models taking deflated price of tea, coffee and sugar as dependent variables. The explanatory variables being own quantity and the quantity of the other items. In all he estimates nine multiple regression equations by ordinary least squares. The notation and results are pre-

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[1] Henry Schultz, The Theory and Measurement of Demand (University of Chicago Press, 1938), pp. 585-589.

[2] Integrability conditions refer to the equality of cross price slopes. If the income effects are small then $\frac{\partial y_c}{\partial x_t} = \frac{\partial y_t}{\partial x_c}$ where y_c, y_t, x_t, x_c are as defined on page . For details see H. Schultz, *op. cit.*, pp. 575-578.

TABLE II.1

THE INTERRELATIONS OF THE DEMANDS FOR SUGAR, TEA, AND COFFEE IN CANADA, 1922–33

x_s, x_t, x_c = Per capita consumption (imports) of sugar, tea, and coffee (in pounds) y_t, y_c = Deflated price of tea and coffee (in cents per pound)
y_s = Deflated price of sugar (dollars per cwt.) t = Time in years, the origin being at January 1, 1928

(The figures in parentheses are standard errors)

Equation Number	Equations							Descriptive Constants
		Constant Term	x_s	x_c	x_t	t	t^2	Adjusted Multiple Correlation Coefficient R'
1	$y_c=$	43.0820	....	−6.1842 (2.6054)	−2.3318 (1.9864)	+0.5613 (0.2633)	−0.0859 (0.0425)	0.7447
2	$y_t=$	65.4313	....	−5.5509 (2.3985)	−4.4499 (1.8287)	+0.5653 (0.2424)	−0.1932 (0.0391)	0.9031
3	$y_s=$	14.4118	−0.1402 (0.0455)	....	+0.2564 (0.6290)	−0.1402 (0.0441)	+0.0291 (0.0125)	0.8128
4	$y_t=$	77.4043	−0.3697 (0.1220)	....	−3.5013 (1.6873)	+0.0787 (0.1184)	−0.2182 (0.0335)	0.9269
5	$y_s=$	14.8228	−0.1531 (0.0497)	+0.6424 (0.9018)	....	−0.2023 (0.0856)	+0.0266 (0.0127)	0.8222
6	$y_c=$	39.6852	−0.0699 (0.1839)	−6.2881 (3.3360)	....	+0.6401 (0.3168)	−0.0853 (0.0470)	0.6905
7	$y_s=$	14.4523	−0.1596 (0.0562)	+0.6258 (0.9649)	+0.2358 (0.6576)	−0.1937 (0.0946)	+0.0266 (0.0136)	0.7937
8	$y_c=$	43.3177	−0.0058 (0.1939)	−6.1244 (3.3312)	−2.3112 (2.2701)	+0.5560 (0.3266)	−0.0862 (0.0469)	0.6925
9	$y_t=$	77.2092	−0.2758 (0.1383)	−3.0205 (2.3765)	−3.4020 (1.6195)	+0.3374 (0.2330)	−0.2063 (0.0334)	0.9330

Source: H. Schultz, op. cit., p. 588.

sented in Table II.1.

The two equations in group one are the only equations which satisfy the integrability condition.

$$\frac{\partial y_c}{\partial x_t} = \frac{\partial y_t}{\partial x_c} \tag{2.1}$$

for they yield the approximate equality

$$\underset{(1.99)}{-2.33} = \underset{(2.40)}{-5.55}$$

The results obtained by the other equations do not satisfy the integrability conditions. Schultz concludes:

> Since the Canadian data are admittedly defective as measures of the consumption of sugar, tea and coffee it is impossible to tell from this experiment whether the assumption of the rationality of human behavior in the market place, which underlies condition (2.1) (in this chapter), is congruent with experience.[1]

Allan Powell[2]

Powell examines the postwar aggregate consumption pattern in Canada. The annual data consists of eight categories of consumption and covers the fifteen year period

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[1] Schultz, op. cit., p. 589.

[2] Alan Powell, "Postwar Consumption in Canada: A First Look at Aggregates", Canadian Journal of Economics and Political Science, Vol. 31, No. 4 (November, 1965), pp. 559-565.

1949-63. He uses a simple linear model which takes the expenditure on a particular commodity group as the dependent variable and the total expenditure and prices of its own and other commodities as explanatory variables. As it is, this model requires the estimation of about eighty coefficients. For this reason Powell assumes that the form of the utility functions is that of "Directly Additive Preferences". Under this assumption the model reduces to a set of equations which can be estimated by an iterative technique. Powell points out that the classification of consumption expenditures he uses is not ideal. He emphasizes the need for a more disaggregated study. His results are as follows.

Only three income coefficients are statistically significant at five per cent level: clothing, household expenses, and transportation. Personal and medical care turned out to be an inferior good. However, this coefficient is not significantly different from zero in a statistical sense.

Except in the case of transportation the Durbin-Watson statistic reveals either positive auto-correlation or the test is inconclusive. No attempt is made in this study to remedy the auto-correlation problem, consequently the t-ratios have to be interpreted with a greater care.

TABLE II.2

POWELL'S ADDITIVE PREFERENCE MODEL PRICE AND INCOME ELASTICITIES OF DEMAND, 1949-63

	Commodity	Elasticity of Demand with Respect to** Income	Own Price	Durbin-Watson Statistic
1.	Food	0.581	-0.464	0.6639†
2.	Tobacco and alcohol	0.793	-0.538	0.6831†
3.	Clothing	0.740*	-0.519	1.0415ξ
4.	Shelter	0.512	-0.379	1.2009ξ
5.	Household expenses	2.134*	-1.275	0.6926†
6.	Transportation	2.325*	-1.365	2.0127
7.	Personal, medical	-0.071	0.051	0.3882†
8.	Miscellaneous	0.973	-0.671	0.5614†

* Significantly different from zero at 5 per cent level under classical assumptions (approximate test only).

† Significant positive autocorrelation at 5 per cent level.

** Elasticities evaluated at mean prices and expenditures.

ξ Test inconclusive.

R.A. Holmes[1]

Estimates of price and income elasticities of demand for just two commodities, beef and pork, have been obtained using annual data for the period 1935-64, excluding the war

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[1] R.A. Holmes, The Estimation of Demand Elasticities for Substitute Food Products (Agricultural Economics Research Council of Canada No. 3, Ottawa, 1966).

years.

The main technique used is the single equation multiple regression fitted by ordinary least squares. He makes various refinements in the model. (1) Data are adjusted for population growth by taking per capita figures. (2) Dummy variables are used to combine pre-war and post-war data. (3) To avoid multi-collinearity, he obtains an income coefficient using cross-section data for the year 1957. The cross-section data are obtained from the D.B.S. family expenditure survey. This extraneous estimate of income coefficient is pooled with the time series data to obtain improved estimates of the other coefficients. This is done by first obtaining the income free residuals by subtracting the income effects from the dependent variables, relative prices of beef and pork. These residuals are in turn used as dependent variables to obtain own and cross price elasticities. (4) To avoid auto-correlation problems, he assumed different values for the auto-correlation coefficient in the range -1.0 to +1.0 with an interval of 0.1. Residual sums of squares are presented for these twenty-one possible transformed regression equations. He chooses that transformation which gives the smallest residual sums of squares. This procedure is equivalent to maximum likelihood estimation of the structural coefficients.[1]

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[1] For a proof of this proposition see R.A. Holmes, op. cit., pp. 97-99 or C. Hildreth and J.Y. Lu, Demand Relations with Auto-Correlated Disturbances (Michigan State University Agricultural Experiment Station, Department of Agricultural Economics, East Lansing, Michigan, Technical Bulletin 270, November, 1960).

The final results presented are

$$PB' = 5.0231 + 0.3798\ X_2 - 1.3528\ QB' - 0.0711\ QP' - 247.8943\ YI + 0.0212\ T$$

$$\rho b = -0.3$$

$$PP' = 3.63 + 0.4690\ X_2 - 0.4704\ QB' - 0.6178\ QP' - 157.8262\ YI - 0.0050\ T$$

$$\rho p = +0.2$$

PB' = logarithm of relative price of beef

PP' = logarithm of relative price of pork

X_2 = dummy variable to combine pre and post-war data

QB' = logarithm of consumption of beef per adult equivalent in pounds

QP' = logarithm of consumption of pork per adult equivalent in pounds

YI = reciprocal of income per person in constant 1949 dollars

T = time trend

ρb, ρp is that value of auto-correlation coefficient which minimized the error sum of squares of the residuals for beef and pork equations respectively.

With these various refinements the direct price elasticities of demand are estimated to be -0.77 for beef and -1.69 for pork. The cross price elasticities are estimated at 0.09 for beef with respect to pork prices and 0.59 for

pork with respect to beef prices. Income elasticities declined over the 1935-64 period from 0.34 to 0.15 for beef, and from 0.23 to 0.10 for pork.

Finally, one should note that pork is not the only substitute for beef. Chicken, eggs, vegetables etc., are all substitutes for beef. Inclusion of these other commodities would, probably, have given somewhat different results.

Houthakker[1]

Houthakker estimates elasticities for the five groups of commodities, viz., food, clothing, rent, durables and miscellaneous, for thirteen countries of which Canada is one. Annual data for the period 1948-59 are used. The dependent variable is per capita expenditure on a particular commodity group. The explanatory variables are relative prices and per capita total expenditure on goods and services in constant dollars. He uses a double logarithmic functional form.[2] The estimation method is ordinary least squares. The results are presented in Table II.3.

These results are not satisfactory. Clothing turns out to be an inferior good! Also the price elasticity of demand for durables has a positive sign which we do not expect

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[1] H.S. Houthakker, "New Evidence on Demand Elasticities", Econometrica, Vol. 33, No. 2 (April, 1965), pp. 277-288.

[2] Houthakker, in justifying the use of logarithmic form notes that Engel also used double log form in his study of 1857.

TABLE II.3

PRICE AND EXPENDITURE ELASTICITIES

Commodity Group	Price Elasticity	Total Expenditure Elasticity
Food	-0.292	0.689
Clothing	-0.376	-0.086
Rent	-0.091	1.266
Durables	0.964	3.438
Miscellaneous	-0.355	0.902

on a priori grounds.

Other Studies

There are some econometric models which incorporate separate equations for nondurable goods, services and durable goods. Officer's[1] and the Bank of Canada model[2] have both a separate equation for the demand for non-durable goods. Since these are highly aggregative in nature and as their objective is not measurement of demand, per se, equations

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[1] Lawrence H. Officer, An Econometric Model of Canada under the Fluctuating Exchange Rates (Harvard University Press, Cambridge, 1968).

[2] John F. Helliwell, Lawrence H. Officer, Harold T. Shapiro, Ian A. Stewart, A Quarterly Model of the Canadian Economy (Bank of Canada Research Department, December, 1968).

estimated in these studies are not presented here.

Part III: Cross-Section Studies

The data for the cross-section studies are obtained from household expenditure surveys. So far Asimakopulos, Houthakker and Kristian Palda have made use of the survey data obtained by the D.B.S. to estimate income or expenditure elasticities of demand. These studies will be reviewed in that order.

Asimakopulos[1]

In his study Asimakopulos makes use of data obtained by 1947-48[2] and 1959[3] expenditure surveys. Asimakopulos has discussed the reliability of the data obtained by these surveys in great detail.[4] The surveys require respondents to recall expenditures on detailed items made during a twelve month period, from one to four months after the end of the period. In the absence of records this could result

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[1] Asimakopulos, "Analysis of Canadian Consumer Expenditure", Canadian Journal of Economics and Political Science, Vol. 31, No. 2 (May, 1965), pp. 222-241.

[2] Canadian Non-Farm Family Expenditures, 1947-48 (D.B.S. Reference Paper No. 42, Ottawa, June, 1953).

[3] Urban Family Expenditure, 1959 (D.B.S. 62-521, Ottawa, March, 1963).

[4] Asimakopulos, *op. cit.*, pp. 223-226.

in substantial errors.

The model used is

$$\log C_i = a_{0i} + a_{1i} \log Y + a_{2i} \log S$$

C_i = expenditure on ith commodity group

Y = measured income

S = family size

a_{1i}, a_{2i} = income and family size elasticities.

When there are errors in the measurement of any one explanatory variable all coefficients are biased, if we use ordinary least squares. The instrumental variable technique is used to avoid the bias due to measurement error. As there are two explanatory variables, two instrumental variables are used.[1] As family size is measured without error, it is used both as instrumental variable and explanatory variable. "Total consumption expenditure" is used as an instrumental variable for "measured income".

Asimakopulos finds very little difference in the estimated parameters by the ordinary least squares technique and the instrumental variable technique. The results of both methods are presented in Table II.4 for the two surveys 1947-48 and 1959.

The commodity groups, food, housing, fuel, etc., furnishing and equipment and clothing are comparable in both

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[1] For details on how the instrumental variables work, see A.S. Goldberger, Econometric Theory (Wiley, New York, 1964), pp. 284-287.

TABLE II.4

INCOME ELASTICITIES OF DEMAND OBTAINED BY ORDINARY LEAST SQUARES (O.L.S.) AND THE INSTRUMENTAL VARIABLE METHOD (I.V.)

	Commodity Group	1947-48 O.L.S.	1947-48 I.V.	1959 O.L.S.	1959 I.V.
1.	Food	.518	.527	.443	.445
2.	Housing, fuel etc.	.837	.847	.518	.519
3.	Furnishing & Equipment	1.126	1.195	1.151	1.163
4.	Clothing	1.044	1.029	.984	.987
5.	Other Consumption Expenditures	1.001	1.024	1.065	1.092

surveys. The commodity group "other consumption expenditures" does not contain the same bundle of goods in the two surveys. The survey results for the year 1959 are presented at a more disaggregated level. Asimakopulos attributes "changes in tastes" to one of the possible factors accounting for the differences in the esimates obtained by the two surveys.

Houthakker[1]

Engel's law, formulated in 1857, states that the pro-

[1] H.S. Houthakker, "An International Comparison of Household Expenditure Patterns Commemorating the Centenary of Engel's Law", Econometrica, Vol. 25, No. 4 (1957), pp. 532-551.

portion of income spent on food decline as income rises. To test this law, Houthakker used data of about forty family expenditure surveys from about thirty countries, of which Canada is one. The technique used is multiple regression analysis and the estimation method is ordinary least squares.

The data used are based on 1947-48 Canadian Non-Farm Family Expenditure Survey.[1] These were also the data used by Asimakopulos. Both Asimakopulos and Houthakker have used the double log functional form. The difference between the two studies is that the former uses disposable income as an explanatory variable, whereas the latter uses total expenditure as an explanatory variable. As expected expenditure elasticities are larger than income elasticities. This is shown in Table II.5.

In these two commodity classifications only food and clothing are comparable. Expenditure elasticities for food and clothing are larger than income elasticities by 25 per cent and 30 per cent respectively.

Kristian S. Palda[2]

This is a study undertaken to compare the regional

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[1] Canadian Non-Farm Family Expenditures, 1947-48 (D.B.S. Reference Paper 42, Ottawa, June, 1953).

[2] Kristian S. Palda, "A Comparison of Consumer Expenditures in Quebec and Ontario", Canadian Journal of Economics and Political Science, Vol. 33, No. 1 (February, 1967), pp. 16-26.

TABLE II.5

A COMPARISON OF THE EXPENDITURE AND INCOME ELASTICITIES OBTAINED BY HOUTHAKKER AND ASIMAKOPULOS

	Commodity Group	Houthakker Expenditure Elasticities	Asimakopulos Income Elasticities
1.	Food	0.647	0.518
2.	Clothing	1.337	1.044
3.	Housing	1.114	
4.	Housing, fuel etc.		0.837
5.	Miscellaneous	1.131	
6.	Furnishing & Equipment		1.126
7.	Other Consumption Expenditures		1.001

patterns of consumption. The two regions chosen are Quebec and Ontario, representing French and English speaking communities respectively.

The data are from the Urban Family Expenditure Survey 1959.[1] Data on expenditures are classified into eleven commodity groups. The dependent variable is the expenditure on a particular item. The explanatory variables are disposable income and the household size.

[1] Urban Family Expenditure, 1959 (D.B.S. 62-521, Ottawa, March, 1963).

Simple linear regression equations performed better (had smaller standard deviations of residuals) than either semi-logarithmic or logarithmic regressions. The estimates reported in the Palda paper are all based on simple linear regression. The income elasticities of demand for Canadian, Quebec and Ontario are presented in Table II.6.

TABLE II.6

SOME CANADIAN, QUEBEC AND ONTARIO INCOME ELASTICITIES, 1959

	Variable	Canadian	Quebec	Ontario
1.	Shelter	.482	.555	.584
2.	Household	.795	.970	1.026
3.	Food	.438	.501	.408
4.	Furnishings	1.025	.695	.818
5.	Personal Care	.806	.760	.614
6.	Clothing	1.072	.900	.850
7.	Medical Care	.584	.653	.458
8.	Recreation	1.126	1.417	.789
9.	Reading	.771	.783	.511
10.	Education	1.309	2.254	1.460

Note: The elasticities presented under the column "Canadian" are taken from Asimakopulos' study reviewed before.
Source: Kristian S. Palda, *op. cit.*, p. 22.

Are the observed differences between Quebec and Ontario elasticities statistically significant? To answer this question Chow's[1] test has been used. Taking a 95 per cent confidence level as a criterion, the expenditure patterns on food, clothing, furnishing, recreation and education were found to be significantly different between the two provinces.

Additional statistical tests have been applied by selecting households of two types. Type 1: Households with one and two children; type 2: households with three and four children. An additional constraint imposed was that the disposable income of these households should neither be less than $2,500 nor exceed $10,000.

Two methods of estimation, the orindary least squares and the Liviatan's[2] method have been used. With the sub-sample data the estimates obtained by ordinary least squares did reveal statistically significant differences between Ontario and Quebec consumption patterns. But the estimates obtained by the Liviatan method did not completely support this hypothesis. However, the estimates obtained by Liviatan's

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[1] Gregory C. Chow, "Test of Equality Between Sets of Coefficient in Two Linear Regressions", Econometrica, Vol. 28 (1960), pp. 591-605.

[2] Liviatan's method is an instrumental variable technique. Kristian Palada uses measured income as an instrumental variable for total expenditure. He compares total expenditure slopes by Liviatan's method as against income slopes in the case of ordinary least squares. Instrumental variable technique due to Liviatan will also be used in Chapter IV. But the problem here and that in Chapter IV are different. In this context it is a problem of simultaneity bias whereas in Chapter IV it is a problem of distributed lag model.

method did support the hypothesis to the extent of 58 per cent of the total consumer expenditures. Thus the results obtained by one of the methods employed only partially supported the hypothesis that the pattern is different for both the provinces.

To sum up, we find that the results obtained by using different budget data are different. The results obtained by different methods of estimation are different. The results between regions are different.

Part IV: Comparison of Time Series and Cross-Section Estimates

Among the studies surveyed so far only the results of three commodity groups -- food, clothing and transportation -- are comparable between time series and cross-section studies. These results are presented in Table II.7.

Cross-section estimates are generally larger than time series estimates. The former represent longrun coefficients. The results of Table II.7 only partially support this proposition. The cross-section estimates of income/expenditure elasticities of demand for clothing are larger than the corresponding time series estimates. But in the case of food and transportation, time series estimates are larger than the cross-section estimates.

One explanatio of this contradiction could be that a year is more than enough for the adjustment of demand for

TABLE II.7

A COMPARISON OF ELASTICITIES OF DEMAND BY TIME SERIES AND CROSS-SECTION STUDIES

Name of Investigator	Food			
	Time series		Cross Section	
	Income	Expend-iture	Income	Expend-iture
Alan Powell 1949-63	0.581			
H.S. Houthakker 1948-59		0.689		
A. Asimakopulos 1947-48			0.518	
A. Asimakopulos 1959			0.443	
H.S. Houthakker 1947-48				0.647
Kristian Palda 1959				
Quebec			0.501	
Ontario			0.408	

TABLE II.7 CONTINUED

Name of Investigator	Clothing			
	Time series		Cross Section	
	Income	Expend-iture	Income	Expend-iture
Alan Powell 1949-63	0.740			
H.S. Houthakker 1948-59		-0.086		
A. Asimakopulos 1947-48			1.044	
A. Asimakopulos 1959			0.984	
H.S. Houthakker 1947-48				1.337
Kristian Palda 1959				
Quebec			0.900	
Ontario			0.850	

TABLE II.7 CONTINUED

Name of Investigator	Transportation	
	Time series Income	Cross-Section Income
Alan Powell 1949-63	2.325	
H.S. Houthakker 1948-59		
A. Asimakopulos 1947-48		
A. Asimakopulos 1959		1.606
H.S. Houthakker 1947-48		
Kristian Palda 1959		
Quebec		1.680
Ontario		1.032

food for a given change in income. For this reason time series estimates could well be equal to the cross-section estimates. However, in the case of transportation the time series estimate is much larger than the corresponding cross-section estimate. This difference is more than 100 per cent if we compare the time series estimate for the whole of Canada (2.325) against Ontario elasticity (1.032).

CHAPTER III

ORDINARY LEAST SQUARES ESTIMATES

This chapter is divided into five parts. In Part I a brief description of the changes in the composition of the commodity groups over the period 1956-65 is presented. In Part II the model used in this chapter and in Chapter IV is given. Also included in this section is a discussion of the problem of "Errors in Variables". Part III is devoted to a discussion of the problem of estimation. The price and income elasticities of demand obtained by applying ordinary least squares to multiple regression equations are presented in Part IV. In Part V an overview of empirical results is presented.

Part I

Fourteen nondurable commodity groups are considered for this econometric study. Quarterly data for the period 1956-65 are used. The composition of the selected fourteen commodity groups is given in Table 3.1. The percentage change in the own price index and the own relative price index are presented in Table 3.2. The relative price index is obtained by deflating the own price index with the consumer price index for all goods and services.

Consumption of nondurable goods forms about half of the total consumption expenditure of goods (durables and

TABLE 3.1

COMPOSITION OF NONDURABLE GOODS OVER THE PERIOD 1956-65. FIGURES REFER TO PERCENTAGE OF EACH ITEM IN THE TOTAL NONDURABLE GOOD EXPENDITURES

		1956	1965
1.	Farm foods	1.68	1.05
2.	Purchased foods	40.81	39.61
3.	Meals	5.21	4.19
4.	Tobacco products	5.28	5.56
5.	Alcoholic beverages	7.70	7.74
6.	Men's clothing	4.71	4.50
7.	Women's clothing	8.51	8.28
8.	Piece goods	0.77	0.61
9.	Notions	0.53	0.38
10.	Footwear	2.47	2.13
11.	Household supplies	1.14	0.90
12.	Soap & cleaning supplies	0.80	0.83
13.	Drugs & cosmetics	3.44	3.44
14.	Newspapers & magazines	1.88	1.66

TABLE 3.2

PERCENTAGE CHANGE IN OWN AND RELATIVE PRICES OVER THE PERIOD 1956-65.

		Percentage Increase in Own Price Index 1956-65	Percentage Increase in Relative Price 1956-65
1.	Farm foods	11.06	-5.49
2.	Purchased foods	19.11	2.56
3.	Meals	19.11	2.56
4.	Tobacco products	13.30	-3.25
5.	Alcoholic beverages	14.17	-2.38
6.	Men's clothing	12.89	-3.66
7.	Women's clothing	6.61	-9.94
8.	Piece goods	13.29	-3.26
9.	Notions	13.29	-3.26
10.	Footwear	22.47	5.92
11.	Household supplies	22.91	6.36
12.	Soap & cleaning supplies	16.41	-0.14
13.	Drugs & cosmetics	14.86	-1.69
14.	Newspapers & magazines	36.00	19.45
15.	All nondurable goods	13.89	-2.66
16.	All goods and services	16.55	0.00

nondurables) and services. Over the period 1956-65 the share of nondurable consumption expenditure in total consumer expenditure has slightly declined.

Examining Table 3.1 we find that food is the single largest item of expenditure, which forms about 45 to 50 per cent of total nondurable goods, followed by clothing and footwear, which forms about 16 per cent. The importance of food products has decreased over the period 1956-65. This is probably consistent with Engel's law, which states that the proportion of expenditure on food decreases as income increases. Tobacco products, alcoholic beverages, and soap and cleaning supplies, among other nondurable goods, have shown an increase in their share of total nondurable consumption expenditures, while the rest have decreased or were constant over the same period.

Table 3.2 reveals that absolute prices of all nondurable goods under study have increased. The relative prices of some goods have increased while some others decreased. However, there is considerable variation in the relative price changes of the different commodity groups.

Part II: The Model

The aim of empirical demand functions is to explain as fully as possible the changes in demand over a period of time. As we are primarily interested in the explanation of "quantity demanded", we take it as the dependent variable.

The most important variables effecting the demand for a commodity are the price of the commodity, prices of substitutes and of complementary goods, and income. For example, in the estimation of a demand function for beef, introduction of the relative price of pork, the relative price of poultry in addition to the relative price of beef is important. This type of specification is employed when we are dealing with highly disaggregated demand functions, like demand for beef, pork, etc. Alternatively one could specify the demand for a commodity as a function only of the relative price and real income. A relative price is obtained by deflating the price of that commodity by an overall consumer price index for goods and services.

The second type of specification, namely the inclusion of relative price and real income in the demand function, is to be used when we are dealing with aggregate commodity groups. Ferber comments:

> The necessity of introducing prices of competing goods depends upon the characteristics of the products studied. In the case of major aggregates, such as total expenditures on clothing, possibilities of direct substitution are less than for individual products. Particularly with individual foods, price substitution plays an important role, and is often found where it would not have been expected on a priori grounds.[1]

Throughout this study only the second type of specification is adopted, as the data are available only for commo-

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[1] R. Ferber and P.J. Verdoorn, Research Methods in Economics and Business (The MacMillan Company, New York, 1962), p. 362.

dity groups.

The time series data are the points obtained by the intersection of the demand and supply curves at different points of time. For various reasons both demand and supply curves shift over time. This raises a problem of identification, which can be solved by specifying a simultaneous equation model consisting of a demand and supply equation. However, many empirical demand studies use only a single equation approach taking prices and income as explanatory variables. It should be noted that such estimates obtained by using a single equation are biased.

A simple multiple regression model is used throughout this chapter. The dependent variable is the expenditure on a particular commodity group in terms of constant 1957 dollars. The explanatory variables in the simplest case are the relative price of the commodity and real disposable income. The notation used throughout this dissertation is presented on pages 41 to 42.

The model used in this study is:

$$Q_t = A_0 + \alpha P_t + \beta Y_t + u_t \tag{3.2.1}$$

Equation (3.2.1) is a multiple regression equation with expenditures on a particular commodity group as the dependent variable (Q_t) and the relative price (P_t) and real disposable income (Y_t) as explanatory variables. u_t is an error term.

The adjustment of demand due to a price change or an

income change is not instantaneous. Due to psychological, institutional and other factors there is a time lag for a complete adjustment of quantity demanded due to a change in prices and income. Assuming a Koyck[1] type of distributed lag model we can write equation (3.2.1) as

$$Q_t = A_0 + \alpha P_t + \alpha\lambda P_{t-1} + \alpha\lambda^2 P_{t-2} + \dots$$
$$+ \beta Y_t + \beta\lambda Y_{t-1} + \dots + u_t \qquad (3.2.2)$$

where λ is the coefficient of adjustment which is assumed to be the same for relative price changes and real income changes.[2] The limits of λ are between 0 and 1. Large values

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[1] L.M. Koyck, Distributed Lags and Investment Analysis (North Holland Publishing Company, Amsterdam, 1954). Koyck in this book derives a distributed lag model assuming a geometrically declining weighting pattern, i.e., the effect of the lagged variables on the current dependent variable declines geometrically.

[2] If we assume different lag schemes for relative price changes and real disposable income the resulting equation to be estimated is overidentified. For the derivation of the equation see Zvi Griliches, "Distributed Lags: A Survey", Econometrica, Vol. 35, No. 1 (January, 1967), p. 45.

The final form of the equation under the assumption of different coefficients of adjustment is

$$Q_t = A_0 + A_1 P_t + A_2 P_{t-1} + A_3 Y_t + A_4 Y_{t-1}$$
$$+ A_5 Q_{t-1} + A_6 Q_{t-2} + \text{disturbance term.}$$

The implied restrictions are (continued on following page)

of λ imply that people adjust slowly for changes in relative prices and real income.

If we lag (3.2.2) once, multiply by λ and subtract from (3.2.2), we obtain the equation

$$Q_t = A_0(1-\lambda) + \alpha P_t + \beta Y_t + \lambda Q_{t-1} + (u_t - \lambda u_{t-1}) \quad (3.2.3)$$

If we take logarithms of the variables in (3.2.3) and estimate

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2 (continued)

$$\frac{A_2}{A_1} + \frac{A_4}{A_3} = -A_5 \text{ and } \frac{A_2}{A_1} \times \frac{A_4}{A_3} = A_6$$

These restriction imply $A_2^2 + A_1^2 A_6 = A_5 A_1 A_2$. Due to these complications involved in estimating such an equation subject to the constraints it was not used in this study. For the commodity group, "Purchased foods" such an equation was estimated by ordinary least squares with little success.

There are some studies which have used the same coefficient of adjustment in the demand for consumer goods and services for a change in either real disposable income or real cash balances. The empirical evidence, cited below, can be used as a partial justification for the method adopted in this study.

(a) Carl Christ, "A Test of an Econometric Model for the United States, 1921-1947", In Conference on Business Cycles (New York, 1951), pp. 59-60.

(b) Arnold Zellner, "The Short-Run Consumption Function", Econometrica, Vol. 25 (1957), p. 560.

(c) Z. Griliches, G.S. Maddala, R. Lucas, N. Wallace, "Notes on Estimated Aggregate Quarterly Consumption Function", Econometrica, Vol. 30 (1962), p. 495.

(d) For other similar studies see Don Patinkin, Money, Interest, and Prices, II Edition (Harper & Row, New York, 1965), pp. 656-657.

the equation, the resulting coefficients α and β represent the short-run price and income elasticities. The long-run price and income elasticities are respectively $\alpha/1-\lambda$ and $\beta/1-\lambda$.[1]

Notation

Y	Aggregate real disposalbe income in constant 1957 dollars.
y	Per capita real disposable income in constant 1957 dollars.
P	Relative price, i.e., the own price index of the commodity group divided by the consumer price index of all goods and services. This also termed "deflated price".
Q	Expenditure on the commodity group in constant 1957 dollars.
q	Per capita expenditure on the commodity group in constant 1957 dollars.
E	Total expenditure on goods and services in constant 1957 dollars.

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[1] Consider the equation (3.2.2)

$$Q_t = A_o + \alpha P_t + \alpha\lambda P_{t-1} + \alpha\lambda^2 P_{t-2} + \ldots.$$

$$+ \beta Y_t + \beta\lambda Y_{t-1} + \ldots + u_t$$

Short-run price elasticity is obviously = α
Long-run price elasticity =

$$\alpha + \alpha\lambda + \alpha\lambda^2 + \ldots\ldots = \frac{\alpha}{1-\lambda}$$

Similarly the long-run income elasticity = $\frac{\beta}{1-\lambda}$

e	Per capita total expenditure on goods and services in constant 1957 dollars. This figure is obtained by dividing E by the population.
YLAG	Lagged value of Y, lag being one quarter = Y_{t-1}
yLAG	Lagged value of y, lag being one quarter = y_{t-1}
PLAG	Lagged value of P, lag being one quarter = P_{t-1}
QLAG	Lagged value of Q, lag being one quarter = Q_{t-1}
qLAG	Lagged value of q, lag being one quarter = q_{t-1}
ELAG	Lagged value of E, lag being one quarter = E_{t-1}
eLAG	Lagged value of e, lag being one quarter = e_{t-1}
ρ	Auto correlation coefficient.
S_1, S_2, S_3	are seasonal dummy variables.
t	time trend. It is also used as a subscript.
R^2	Square of the multiple correlation coefficient.
R^{-2}	Adjusted value of R^2
D.W.	Durbin-Watson statistic.

The following eight variations of the basic model (3.2.1) are used in this chapter and are given in Table 3.2b. For notation see pages 41-42.

Equations (1) and (2) are the demand equations for a commodity group based on aggregate data. In equation (1) the major explanatory variable is total expenditure on goods and services. In equation (2) the important explanatory variable is real disposable income. Equations (3) and (4) are extensions of equations (1) and (2) taking into account the lagged behaviour of the consumers by using a distributed lag model. Equations (5), (6), (7) and (8) are similar to equations (1), (2), (3) and (4) except that they are based on

TABLE 3.2b

VARIATIONS OF THE BASIC MODEL (3.2.1)

Equation No.	Type	Specification[1]
	Aggregate data	
1	Simple	$Q = A_0 + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta E + u$
2	Model	$A = A_0 + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta Y + u$
3	Distributed	$Q = A_0' + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta E + \lambda QLAG + v$
4	Lag Model	$Q = A_0' + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta Y + \lambda QLAG + v$
	Per Capita data	
5	Simple	$q = A_0 + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta e + u$
6	Model	$q = A_0 + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta y + u$
7	Distributed	$q = A_0' + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta e + \lambda qLAG + v$
8	Lag model	$q = A_0' + A_1S_1 + A_2S_2 + A_3S_3 + \alpha P + \beta y + \lambda qLAG + v$

[1] For simplicity the time subscripts have been excluded. In actual estimation of these multiple regression equations double log form is used.

per capita data.

Expenditure vs. Income

In equations (1), (3), (5) and (7) total expenditure on goods and services is the relevant explanatory variable, whereas in equations (2), (4) (6) and (8) real disposable income is the relevant explanatory variable. Consumer decisions respecting the expenditure on a particular commodity group could be viewed as a function of income. Alternatively it can be thought of as a two-stage decision. First, the consumer may decide as to how he is going to divide disposable income into consumption and saving. At the second stage the amount he is going to spend on each commodity group will be decided on. For this reason both total expenditure on goods and services and real disposable income have been used as alternative explanatory variables.

We expect the expenditure elasticity of demand to be larger than the income elasticity of demand. As income increases a greater percentage of income will be saved. So the proportionate change in total expenditure will be less than the proportionate change in total income.

Aggregate vs. Per Capita

Per capita figures are obtained by simply dividing the aggregate data by the population . Regression equations have been estimated using both aggregate and per capita data. As the population increases the demand for a product increases.

To eliminate this trend, per capita data are used.

As family size increases, more food, clothing, etc. will be bought, but not exactly in the same proportion as the increase in family size. For example, a family of three children and another family of four children may both have the same amount of expenditure on newspapers and magazines. In addition certain economies of scale are realized in large scale purchases. For this reason estimates are obtained by using the aggregate data as well.

Data

The data on different variables are taken from the 'Data Bank', supplied jointly by the D.B.S. and the Bank of Canada. The data have many limitations. An account of the limitations of the data is given in Appendix II. The available data are not seasonally adjusted. Dummy variables have been used to eliminate the seasonal variation.

The Problem of Errors in Variables

As the data employed are not of a high quality some measurement errors can be expected both in the dependent variable and in the explanatory variables. Ordinary least squares estimates in such a context are biased and inconsistent. In the case of one dependent variable with one explanatory variable the approximate size of the bias is as follows.[1]

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[1] J. Johnson, Econometric Methods (McGraw-Hill, 1960) pp. 148-50.

Let us assume

$$X = \chi + u \tag{3.2.4}$$

$$Q = \psi + v \tag{3.2.5}$$

where X and Q indicate observed (measured) values, χ and ψ the true values, and u and v errors of observation. Suppose that the true values are connected by the relation

$$\psi = \alpha + \beta\chi \tag{3.2.6}$$

solving equations (1), (2), and (3) we have the model

$$Q = \alpha + \beta X + W \tag{3.2.7}$$

where $\qquad W = (v - \beta u)$

Even if the errors u and v are assumed to be mutually and serially independent with constant variances, and also to be independent of the true values χ and ψ, the full assumptions for the application of simple least squares to equation (4) to obtain estimates of α and β are not met, since W is not independent of X. The covariance of X and W is

$$\begin{aligned} E\{W[X - E(X)]\} &= E[(v - \beta u)(\chi + u - \chi)] \\ &= E[(v - \beta u)(u)] \\ &= -\beta \text{ Var } (u) \end{aligned}$$

on the assumption that $E(v) = E(u) = 0$, so that $E(X) = \chi$. Since this covariance does not vanish, a dependence exists between the error term and the explanatory variable in equation (3.2.7).

The consequence of this dependence is that the straight forward application of least squares to (4) would yield biased estimates of the parameters α and β. Furthermore the bias will not disappear as the sample size increases. That is the least squares estimates are inconsistent. It can be shown that[1]

$$\text{Plim } b = \frac{\beta}{1 + \frac{\sigma_u^2}{\sigma_\chi^2}}$$

where σ_u^2 is the variance of u and σ_χ^2 is the variance of χ and b is the ordinary least squares estimate of β. Thus the application of ordinary least squares gives inconsistent estimates of the parameters. It should be noted that, if there are errors in variables, estimates obtained by Liviatan's technique[2] and modified form of Zellner's efficient estimation of seemingly unrelated regressions[3] are also biased and in-

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[1] For Proof see J. Johnston, op. cit., p. 150.

[2] The method in more detail is described in Chapter IV.

[3] The method in more detail is described in Chapter V.

inconsistent.[1] In the interpretation of the regression coefficients and in comparing the estimates by different methods employed in the thesis we should note that these estimates are all subject to bias arising out of errors in variables. The question is how serious these biases are. In this context it is interesting to note Malinvaud's comment.[2]

"In fact this assumption (the assumption of measurement of variables without error) is often justified. While statistical data are generally liable to be imperfect in many respects, they still have enough precision to allow us to estimate relations, which are not themselves exact. In other words, the errors affecting the equations are in most cases of much greater importance than those which may affect measurement of the variables".

There is also some empirical evidence in support of this comment. Asimakopulos in the analysis of Canadian consumer expenditure used a multiple regression model. He estimated the regression coefficients with ordinary least squares method. To solve the problem of measurement errors he also applied instrumental variable technique. He found

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[1] The algebra in deriving the exact expressions for asymptotic bias in these cases is more complicated. But the reason for the inconsistency in the estimates is the same as that for ordinary least squares, namely, the explanatory variable is correlated with the error term.

[2] E. Malinvaud, Statistical Methods of Econometrics (Rand McNally & Company, 1966), p. 326.

very little difference in the estimated parameters by the ordinary least squares technique and the instrumental variable technique.[1]

Although the presence of measurement errors result in inconsistent estimates by all the methods employed in this thesis the above comment and empirical evidence suggests that the magnitude of such errors is not of much importance.

Part III: Estimation

The multiple regression equations (1), (2), (5) and (6), presented on page 43, can be estimated using the ordinary least squares method of estimation. We assume that the disturbances in these equations meet all the assumptions required for the application of ordinary least squares. The problem of multicollinearity, which is one of degree, can be reduced by making use of disaggregated data. Prais, arguing for a disaggregated approach in the estimation of import and export demand functions, comments:

> A possibility is to work not with aggregate imports or exports, but with individual commodities or commodity groups. The main advantage is that these show more variation over time than do the aggregates and there is consequently more hope of disentangling the various determining factors at work. A further advan-

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[1] A. Asimakopulos, op. cit. A summary of this article with the relevant results is presented on pages 21-23 of this thesis.

tage is that it mitigates the index number problem.[1] In this study fairly disaggregated data are used. Therefore, the multicollinearity problem should not be too serious.

The assumption of independence of regression disturbances over time is tested by using the Durbin-Watson Statistic. As the range of inconclusiveness is large in this test statistic, the Theil-Nagar[2] approximation is used. In those equations which revealed significant and large autocorrelation, an attempt is made to obtain improved estimates using a first-order autoregressive transformation.

The estimation problem is more complicated when we have a distributed lag model as in the case of equations (3), (4), (7) and (8). When the lagged value of the dependent variable appears as an explanatory variable the use of ordinary least squares method results in esimtates which are not even consistent.[3] In such a case the Durbin-Watson statistic

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[1] S.J. Prais, "Econometric Research in International Trade - A Review", Kyklos, Vol. 15 (1962), p. 564.

[2] H. Theil and A.L. Nagar, "Testing the Independence of Regression Disturbances", The Journal of American Statistical Association, Vol. 56, No. 296 (December, 1961), pp. 793-806.

[3] For a proof of the following result see Z. Griliches, "A Note on the Serial Correlation Bias in Estimates of Distributed Lags", Econometrica, Vol. 29, (continued)

is asymptotically biased towards 2.[1]

Even though the ordinary least squares method results in estimates which are biased, we use that method only in

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3 (continued) No. 1 (1961) pp. 65-73.

The large sample bias of the simple least squares coefficient of y_{t-1} in the model

$$y_t = \alpha x_t + \beta y_{t-1} + u_t$$

with serially correlated disturbances

$$u_t = \rho u_{t-1} + v_t$$

is

$$\text{Plim } (b-\beta) = \frac{\rho(1-\beta^2)}{1 + \rho\beta} \cdot \frac{1}{1 + \frac{\alpha^2 \sigma^2_{z-1.x}}{\sigma^2_w}}$$

where $z_t = \sum_i \beta^i x_{t-i}$

$$w_t = \sum_i \beta^i u_{t-i}$$

$$\sigma^2_{z-1.x} = \sigma^2_{z-1} (1 - r^2 x.z-1)$$

$\sigma^2_{z-1.x}$ is that part of the variance of z which is uncorrelated with x_{t+1}. We should note that if $\rho > 0$, b will over estimate β. The Durbin-Watson Statistic is also biased for the same reason.

[1] M. Nerlove and K.F. Wallis, "Use of the Durbin-Watson Statistic in Inappropriate Situations", Econometrica, Vol. 34, No. 1 (1966), pp. 235-239.

this chapter because of (1) ease of estimation; (2) its use in many econometric studies of distributed lag models. In this chapter the results of about 140 multiple regression equations, of which 70 have the lagged value of the dependent variable as an explanatory variable, estimated by the ordinary least squares method, are presented.

Part IV - The Results

The results for the fourteen commodity groups, viz., farm foods, purchased foods, meals, tobacco products, alcoholic beverages, men's clothing, women's clothing, piece goods, notions, footwear, household supplies, soap and cleaning supplies, drugs and cosmetics, and newspapers and magazines, are presented in that order in Tables 3.3 to 3.16. The results for the three aggregate commodity groups, viz., all nondurable goods, all food, and all nondurable goods excluding food, are presented in Tables 3.17, 3.18 and 3.19 respectively. The estimated coefficients obtained by applying ordinary least squares for the eight different models specified in part II of this chapter are presented in each table. There are eight estimated equations in each table. The first four refer to aggregate data and the last four to per capita data. Equations (3), (4), (7) and (8) in each table give the results of the distributed lag models. The

functional form adopted is double-logarithmic.[1] The relevant regression coefficients are therefore elasticities.

The coefficients of the relative price (price elasticity), total expenditure (expenditure elasticity) or real disposable income (income elasticity), lagged value of the dependent variable, adjusted coefficient of multiple determination ($\bar{R}^2$), and Durbin-Watson statistic (D.W.) are presented in each of the eight equations in every table. Only those regression coefficients which are statistically significant at 5% level of significance are presented. The regression coefficients which are not statistically significant (N.S.) are not presented. The constant term and the coefficients of seasonal dummy variables are also not presented. Additional regression equations have been estimated in the case of meals, notions, and household supplies. These estimated regression equations, along with t-ratios in parenthesis, are presented in discussing the results of these commodity groups.

In what follows, comments on the results of each commodity group will be made. These include a discussion of the nature of the commodity group, the importance of own relative price and real income in its demand, and the evidence

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[1] All these equations have also been estimated using a simple linear form. These results are not presented here. Judging the results on the basis of the coefficient of multiple determination and the signs for price and income elasticities, we noted agreement between these two sets of results.

TABLE 3.3

FARM FOODS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.3.1	N.S.	-0.66			0.99	1.28
3.3.2	N.S.		-0.62		0.99	1.36
3.3.3	N.S.	-0.51		N.S.	0.99	1.58
3.3.4	N.S.		-0.46	0.27	0.99	1.67
Per Capita						
3.3.5	0.50	-2.08			0.99	0.79
3.3.6	0.62		-1.8		0.98	1.16
3.3.7	N.S.	-1.05		0.50	0.99	1.61
3.3.8	N.S.		-0.83	0.56	0.99	1.80

TABLE 3.4

PURCHASED FOODS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.4.1	-1.28	0.80			0.98	0.92
3.4.2	-1.46		0.76		0.95	1.35
3.4.3	-0.87	0.48		0.40	0.98	1.96
3.4.4	-0.72		0.30	0.60	0.98	2.27
Per Capita						
3.4.5	-1.09	0.58			0.95	1.38
3.4.6	-1.15		0.50		0.91	1.56
3.4.7	-0.93	0.47		0.20	0.95	1.88
3.4.8	-0.83		0.32	0.36	0.92	2.12

TABLE 3.5

MEALS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\overline{R}^2$	D.W.
Aggregate						
3.5.1	N.S.	0.32			0.87	0.77
3.5.2	N.S.		0.30		0.87	0.81
3.5.3	N.S.	0.14		0.64	0.92	2.10
3.5.4	N.S.		0.12	0.66	0.92	2.13
Per Capita						
3.5.5	N.S.	-0.25			0.70	0.48
3.5.6	N.S.		-0.22		0.70	0.49
3.5.7	N.S.	N.S.		0.85	0.90	2.34
3.5.8	N.S.		N.S.	0.84	0.90	2.31

TABLE 3.6

TOBACCO PRODUCTS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.6.1	N.S.	0.91			0.79	1.16
3.6.2	N.S.		0.85		0.76	1.28
3.6.3	N.S.	0.52		0.41	0.82	1.72
3.6.4	N.S.		0.42	0.48	0.81	1.83
Per Capita						
3.6.5	N.S.	0.71			0.61	1.22
3.6.6	N.S.		0.58		0.58	1.31
3.6.7	N.S.	0.42		0.38	0.66	1.73
3.6.8	N.S.		0.30	0.42	0.64	1.81

TABLE 3.7

ALCOHOLIC BEVERAGES

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.7.1	-1.40	0.84			0.98	1.96
3.7.2	-1.18		0.78		0.97	2.06
3.7.3	-1.43	0.90		N.S.	0.98	1.83
3.7.4	-1.21		0.57	0.28	0.98	2.43
Per Capita						
3.7.5	-1.25	0.70			0.98	1.96
3.7.6	-1.11		0.59		0.97	2.06
3.7.7	-1.25	0.76		N.S.	0.98	1.80
3.7.8	-1.14		0.49	N.S.	0.97	2.31

TABLE 3.8

MEN'S CLOTHING

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\overline{R}^2$	D.W.
Aggregate						
3.8.1	N.S.	0.82			0.99	2.23
3.8.2	N.S.		0.76		0.99	2.34
3.8.3	N.S.	0.77		N.S.	0.99	2.32
3.8.4	N.S.		0.50	0.35	0.99	2.65
Per Capita						
3.8.5	N.S.	0.67			0.99	2.23
3.8.6	N.S.		0.56		0.98	2.30
3.8.7	N.S.	0.62		N.S.	0.99	2.35
3.8.8	N.S.		0.41	N.S.	0.98	2.57

TABLE 3.9

WOMEN'S CLOTHING

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.9.1	-0.75	0.65			0.99	2.50
3.9.2	-0.81		0.60		0.99	2.41
3.9.3	-0.82	0.75		N.S.	0.99	2.15
3.9.4	-0.82		0.62	N.S.	0.99	2.35
Per Capita						
3.9.5	-0.49	0.38			0.99	2.41
3.9.6	-0.51		0.31		0.99	2.39
3.9.7	-0.54	0.46		-0.17	0.99	2.02
3.9.8	-0.56		0.36	N.S.	0.99	2.10

TABLE 3.10

PIECE GOODS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.10.1	-0.72	0.29			0.93	1.65
3.10.2	-0.76		0.26		0.93	1.70
3.10.3	N.S.	0.26		N.S.	0.94	1.79
3.10.4	-0.66		0.23	N.S.	0.93	1.91
Per Capita						
3.10.5	N.S.	-0.37			0.93	1.50
3.10.6	N.S.		-0.36		0.93	1.43
3.10.7	N.S.	-0.33		N.S.	0.93	1.76
3.10.8	N.S.		-0.33	N.S.	0.93	1.71

TABLE 3.11

NOTIONS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.11.1	-2.79	-0.20			0.97	1.78
3.11.2	-2.76		-0.20		0.97	1.71
3.11.3	-2.46	-0.18		N.S.	0.97	1.97
3.11.4	-2.42		-0.18	N.S.	0.97	1.92
Per Capita						
3.11.5	-1.81	-1.3			0.96	0.93
3.11.6	-1.70		-1.15		0.95	0.93
3.11.7	-1.02	-0.75		0.45	0.97	1.86
3.11.8	-0.86		-0.62	0.50	0.97	1.84

TABLE 3.12

FOOTWEAR

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.12.1	N.S.	0.45			0.98	1.32
3.12.2	N.S.		0.39		0.97	1.47
3.12.3	N.S.	0.32		0.34	0.98	2.01
3.12.4	N.S.		0.25	0.38	0.98	2.19
Per Capita						
3.12.5	N.S.	N.S.			0.98	1.99
3.12.6	N.S.		N.S.		0.98	1.96
3.12.7	N.S.	N.S.		N.S.	0.98	1.97
3.12.8	N.S.		N.S.	N.S.	0.98	1.95

TABLE 3.13

HOUSEHOLD SUPPLIES

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\overline{R}^2$	D.W.
Aggregate						
3.13.1	-2.26	0.54			0.99	1.13
3.13.2	-2.12		0.49		0.99	1.25
3.13.3	-1.69	0.41		N.S.	0.99	1.55
3.13.4	-1.34		0.32	0.41	0.99	1.86
Per Capita						
3.13.5	-2.95	0.41			0.99	0.83
3.13.6	-2.85		0.33		0.99	0.91
3.13.7	-1.16	0.25		0.67	0.99	2.03
3.13.8	-1.09		0.22	0.69	0.99	2.14

TABLE 3.14

SOAP AND CLEANING SUPPLIES

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.14.1	N.S.	0.89			0.92	2.29
3.14.2	N.S.		0.82		0.89	2.37
2.14.3	N.S.	0.93		N.S.	0.91	2.16
3.14.4	N.S.		0.71	N.S.	0.89	2.62
Per Capita						
3.14.5	N.S.	0.76			0.72	2.40
3.14.6	N.S.		0.64		0.67	2.49
3.14.7	N.S.	0.85		N.S.	0.72	2.13
3.14.8	N.S.		0.64	N.S.	0.66	2.51

TABLE 3.15

DRUGS AND COSMETICS

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.15.1	-0.32	0.82			0.98	1.06
3.15.2	N.S.		0.77		0.97	1.50
3.15.3	-0.27	0.37		0.54	0.99	2.23
3.15.4	-0.25		0.17	0.77	0.99	2.54
Per Capita						
3.15.5	-0.46	0.60			0.97	1.19
3.15.6	-0.52		0.51		0.96	1.47
3.15.7	-0.37	0.37		0.38	0.98	2.01
3.15.8	-0.35		0.20	0.60	0.97	2.33

TABLE 3.16

NEWSPAPERS AND MAGAZINES

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.16.1	-0.76	0.85			0.99	1.29
3.16.2	-0.66		0.76		0.99	1.57
3.16.3	-0.52	0.55		0.40	0.99	2.03
3.16.4	-0.33		0.34	0.61	0.99	2.27
Per Capita						
3.16.5	-0.82	0.74			0.99	1.27
3.16.6	-0.73		0.58		0.99	1.46
3.16.7	-0.55	0.51		0.37	0.99	2.03
3.16.8	-0.37		0.32	0.52	0.99	2.18

TABLE 3.17

ALL NONDURABLES

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.17.1	N.S.	0.84			0.99	1.81
3.17.2	N.S.		0.78		0.98	2.10
3.17.3	N.S.	0.63		0.26	0.99	2.65
3.17.4	N.S.		0.25	0.70	0.99	3.07
Per Capita						
3.17.5	N.S.	0.71			0.99	2.07
3.17.6	N.S.		0.59		0.97	2.17
3.17.7	N.S.	0.63		N.S.	0.99	2.44
3.17.8	N.S.		0.28	0.55	0.98	2.95

TABLE 3.18

ALL FOOD

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.18.1	-1.08	0.71			0.98	1.11
3.18.2	-1.25		0.67		0.96	1.48
3.18.3	-0.83	0.50		0.31	0.99	1.97
3.18.4	-0.69		0.30	0.56	0.98	2.27
Per Capita						
3.18.5	-0.85	0.42			0.97	2.05
3.18.6	-0.89		0.36		0.95	1.89
3.18.7	-0.87	0.44		N.S.	0.97	1.98
3.18.8	-0.82		0.32	N.S.	0.95	2.05

TABLE 3.19

ALL NONDURABLES EXCLUDING FOOD

Equation No.	Relative Price	Total Expenditure on Goods & Services	Real Disposable Income	Lagged Dependent Variable	$\bar{R}^2$	D.W.
Aggregate						
3.19.1	N.S.	1.04			0.99	2.17
3.19.2	N.S.		0.97		0.98	2.34
3.19.3	N.S.	0.96		N.S.	0.99	2.33
3.19.4	N.S.		0.59	0.42	0.98	2.97
Per Capita						
3.19.5	N.S.	1.05			0.98	2.17
3.19.6	N.S.		0.89		0.96	2.33
3.19.7	N.S.	1.00		N.S.	0.98	2.34
3.19.8	N.S.		0.58	0.38	0.97	2.94

for lagged behaviour. As we are more interested in income elasticities of demand than in expenditure elasticities, most of the discussion will be based on equations (2) and (6) in each table.

Farm Foods (Table 3.3)

The group "farm foods" consists of food produced and consumed on farms. It is one of the imputed items in national income and expenditure accounts, and includes the estimated value of all types of home-grown produce consumed by farm families and hired help, based on average farm prices.

Equations (3.3.2) and (3.3.6) show that farm foods is an inferior commodity. The share of farm foods in total nondurable goods consumption has declined over the period 1956-65. Even in absolute terms the expenditure on farm foods in constant 1957 dollars has declined over the same period. This point supports the claim that it is an inferior commodity. The aggregate data reveal that the price coefficient is not significant but the per capita data reveal a positive and significant price coefficient. However, there is serial correlation in the disturbances, as revealed by the D.W. statistic in equations (3.3.5) and (3.3.6).

As the data in this group are imputed figures, bias must be suspected. For this reason no attempt is made to improve these results. Nevertheless, since the income and expenditure coefficients are relatively large and negative, one can tentatively conclude that this category is an

inferior commodity.

Purchased Food (Table 3.4)

This item includes the food items bought in grocery stores. We expect the income elasticity of demand to be less than unity as food is a necessary[1] commodity. The results are as expected. In all the equations we find that the coefficient of income or expenditure is consistently less than unity. Also equation (3.4.6) reveals no serial correlation in the disturbances. Equations (3.4.1) and (3.4.2), based on aggregate data, show some serial correlation in the disturbances. The price elasticity of demand is about unity. The distributed lag equations (3.4.3), (3.4.4), (3.4.7) and (3.4.8) reveal that the lag is significant.

Meals (Table 3.5)

We expect the income elasticity of demand for this item to be greater than unity as restaurant meals are thought to be a luxury good. The results are not as expected. Equations based on aggregate data reveal a very low income elasticity of demand and an inelasticity with respect to price. Unfortunately, per capita results show that it is an inferior commodity. With per capita equations the value of $\bar{R}^2$ is

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[1] It is more convenient to define "necessities" and "luxuries" in terms of income elasticity of demand than price elasticity. See M. Friedman, Price Theory (Aldine Publishing Company, Chicago, 1962), p. 22.

only .70 and the disturbances are autocorrelated. The size of the autocorrelation coefficient is about .8. To improve the results, first time trend was introduced to take into account the possible changes in tastes. The estimated equation is

$$\begin{aligned} \log q = 1.78 &- \underset{(5.4)}{0.09} \log S_1 + \underset{(6.0)}{0.009} \log S_2 \\ &+ \underset{(3.5)}{0.075} \log S_3 - \underset{(7.8)}{0.053} \log t \\ &- \underset{(0.3)}{0.10} \log P + \underset{(3.4)}{0.30} \log y \end{aligned} \tag{3.5.9}$$

$$\bar{R}^2 = 0.91, \text{ D.W.} = 0.97.$$

Inclusion of time trend improved the results. Income elasticity of demand with per capita data is not negative. It is positive but low. However, D.W. statistic reveals an autocorrelation coefficient of size .51. To improve the estimates an auto-regressive transformation was adopted. Assuming that the transformed disturbances of equation (3.5.9) are uncorrelated, the following equation was estimated.

$$\begin{aligned} (\log q_t - 0.51 \log q_{t-1}) = 0.88 \\ - \underset{(7.0)}{0.09} (\log S_{1t} - .51 \log S_{1t-1}) \end{aligned}$$

$$+ \underset{(.85)}{.01} (\log S_{2t} - .51 \log S_{2t-1})$$

$$+ \underset{(3.5)}{.09} (\log S_{3t} - .51 \log S_{3t-1})$$

$$- \underset{(3.42)}{.05} (\log t - .51 \log t-1) \tag{3.5.10}$$

$$- \underset{(1.23)}{0.52} (\log P_t - .51 \log P_{t-1})$$

$$+ \underset{(2.23)}{.28} (\log y_t - .51 \log y_{t-1})$$

$$\bar{R}^2 = .93, \text{ D.W.} = 1.85$$

The transformed regression equation improved results considerably. The income elasticity of demand is around 0.3. Although the regression coefficient of relative price is not significant, the t-ratio is larger than unity in the transformed equation (3.5.10). This is an example as to how improved statistical techniques can change our conclusions.

We expect "meals" to be a luxury good. The data does

not support this hypothesis.[1] The data supports the hypothesis that it is a necessary good.

All Food (Table 3.18)

An aggregate demand function for food has been fitted combining the first three groups; farm foods, purchased foods, and meals. The results are presented in Table 3.18. These results are quite satisfactory, as revealed by the high value of $\bar{R}^2$ and a Durbin-Watson Statistic close to '2', especially in per capita equations. That food is a necessity is revealed by the fact that the price and income elasticities of demand are less than unity.

Tobacco Products (Table 3.6)

The results show that income is the only variable significantly affecting the demand for tobacco products. That the lag is significant in the demand can be seen from equations (3.6.3), (3.6.4), (3.6.7) and (3.6.8). Although the D.W. statistic reveals presence of positive serial correlation, the size of the correlation coefficient is not large. For this reason no attempt is made to fit a transformed regression equation. Even after the transformation the results would most likely not be very much different.

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[1] Part of this can be attributed to the limitations of the data. As can be seen from Appendix II, (Tables A.8 and A.10) the price indexes of purchased foods and meals are exactly the same. In an economy like Canada, we expect the price increases in meals to be larger than the price increases in purchased food because meals is a service intensive (labor intensive) commodity.

Alcoholic Beverages (Table 3.7)

Both relative prices and real income are significant and have the expected sign in the demand for alcoholic beverages. The lag is significant but very small in size. The results are quite good, as $\bar{R}^2$ is more than 0.97 and the disturbances are not correlated.

Men's Clothing (Table 3.8) and Women's Clothing (Table 3.9)

In equations for men's and women's clothing, the high value of $\bar{R}^2$ coupled with no autocorrelation in the disturbances reveals that the fit is quite good. While income is the only variable affecting the demand for men's clothing, both relative prices and real income are significant in the demand for women's clothing. In men's clothing there appears to be some lag but it is not pronounced. With aggregate data the coefficient of adjustment is just around the significant level and very small in size. The complete absence of lag in women's clothing is probably due to women's greater concern for clothes.

Piece Goods (Table 3.10) and Notions (Table 3.11)

The commodity group "piece goods" includes pieces of cloth bought. The commodity group "notions" includes buttons, thread and other stitching material. We expect the income elasticity of demand for both these commodities to be negative. This is because as income goes up consumers shift their purchases to new and ready-made clothes rather than

have their old clothes mended.

The results based on per capita data in the case of piece goods support our prior expectation that "piece goods" is an inferior commodity group. There is no serial correlation in the disturbances and the value of $\bar{R}^2$ is quite high.

As there is serial correlation in the per capita equations for notions, an autoregressive transformation was made, the result of which is given below.

$$
\begin{aligned}
(\log q_t - .535 \log q_{t-1}) = 0.48 \\
& - \underset{(30.3)}{0.58} (\log S_{1t} - 0.535 \log S_{1t-1}) \\
& - \underset{(31.6)}{0.60} (\log S_{2t} - 0.535 \log S_{2t-1}) \\
& - \underset{(13.5)}{0.41} (\log S_{3t} - 0.535 \log S_{3t-1}) \\
& - \underset{(4.05)}{2.52} (\log P_t - 0.535 \log P_{t-1}) \\
& - \underset{(6.27)}{0.87} (\log y_t - 0.535 \log y_{t-1})
\end{aligned}
\tag{3.11.9}
$$

$R^2 = .98$, D.W. $= 2.21$

As the transformed regression equation (3.11.9) presents no serial correlation in the disturbances, we accept the equation (3.11.9) and reject the per capita results presented in Table (3.11).

We conclude that "notions" are inferior goods. The results confirm our prior expectation.

Footwear (Table 3.12)

The results of footwear on the basis of aggregate data reveals that income is the only variable affecting the demand, while relative prices have no significance. The size of the autocorrelation coefficient is very small. The distributed lag model results show that the lag is important. The per capita results show that neither the price nor the real income coefficient is statistically significant. This can be attributed to the problem of multicollinearity, because we have a high value of $\bar{R}^2$ and the Durbin-Watson statistic is around '2'.

Household Supplies (Table 3.13)

This commodity group includes paint, linens, towels, kitchen utensils, silverware, wallpaper, etc. As this is

a necessary commodity we expect the income elasticity of demand to be less than unity. Both relative prices and real disposable income affect the demand for household supplies. Although $\bar{R}^2$ is quite high both the aggregate and per capita equations reveal presence of positive and significant serial correlation in the disturbances. An autoregressive transformation, along with the inclusion of time trend improved the results. The estimated equation is

$$
\begin{aligned}
(\log q_t - 0.535 \log q_{t-1}) = 0.11 \\
&- \underset{(53.9)}{0.70} (\log S_{1t} - 0.535 \log S_{1t-1}) \\
&- \underset{(11.0)}{1.25} (\log S_{2t} - 0.535 \log S_{2t-1}) \\
&- \underset{(7.64)}{0.19} (\log S_{3t} - 0.535 \log S_{3t-1}) \\
&- \underset{(1.81)}{0.0012}\, t - \underset{(3.46)}{1.66} (\log P_t - 0.535 \log P_{t-1}) \\
&+ \underset{(3.04)}{0.40} (\log y_t - 0.535 \log y_{t-1})
\end{aligned}
\qquad (3.13.9)
$$

$R^2 = .99$, D.W. = 1.56

We note that the auto-regressive transformation has improved the results. The transformed disturbances are almost independent. The income elasticity of demand is 0.40, which is in conformity without prior expectation.

Soap and Cleaning Supplies (Table 3.14)

The results for soap and cleaning supplies reveal that the current real disposable income is the only significant variable. That this commodity group is a necessity is revealed by the fact that the income elasticity of demand is less than unity. Both the aggregate data and the per capita data reveal that the disturbances are uncorrelated. The lag in the consumer response to changes in the relevant explanatory variables is not significant, as revealed by the distributed lag equations in Table (3.14).

Drugs and Cosmetics (Table 3.15)

The results reveal that both relative prices and real income affect the demand with a certain lag. The results of this commodity group, especially equations (3.15.2) and (3.15.6), are satisfactory as $\bar{R}^2$ is high and the disturbances are almost serially independent.

Newspapers and Magazines (Table 3.16)

The results reveal that both relative prices and real income affect the demand with a certain lag. The results of this commodity group, especially equations (3.16.2) and

(3.16.6), are satisfactory as $\overline{R}^2$ is quite high and the disturbances are almost serially independent. We conclude that this tiem is a necessity as the income elasticity of demand is less than unity.

<u>All Nondurable Goods (Table 3.17) and All Nondurable Goods Excluding Food (Table 3.19)</u>

The demand for some commodities, viz., food, alcoholic beverages, women's clothing, notions, household supplies, drugs and cosmetics and newspapers and magazines, was influenced by relative prices. When we aggregate we do not find any such evidence either in the demand for all nondurable goods (Table 3.17) or in the demand for all nondurable goods excluding food (Table 3.19). Aggregation, therefore, resulted in loss of some relevant information.

Most of the nondurable goods considered in this study are necessities. We, therefore, expect the income elasticity of demand for "all nondurable goods" and "all nondurable goods excluding food" to be less than unity. The results support our prior knowledge as the income elasticity of demand for "all nondurable goods" is less than unity. We find that the income elasticity of demand for "all nondurable goods is less than the income elasticity of demand for "all nondurable goods excluding food". This is because the income elasticity of demand for "all food" (Table 3.18) is less than the income elasticity of demand for "all nondurable goods".

Part V: Summary of the Empirical Results

In general, the results are quite satisfactory as revealed by high value of $\bar{R}^2$, expected signs for most of the estimated coefficients, and serially uncorrelated disturbances. The income elasticities based on aggregate data were always larger than the income elasticities based on per capita data. This is expected because the per capita elasticities are obtained by adjusting for population growth.[1] As expected expenditure elasticities were always larger than income elasticities.

The role of real income seems to be bigger than that of relative prices in the consumer demand for nondurable goods in the Canadian economy. This is revealed in Table 3.20. Real disposable income is significant in all the commodity groups except for per capita data in the case of "footwear". Relative prices are clearly significant (i.e., both with aggregate data and per capita data) only in six commodity groups. In three commodity groups they are either

---

[1] Per capita income elasticity of demand can be shown to be equal to

$$\frac{d(Q/n)}{d(Y/n)} \cdot \frac{Y/n}{Q/n} = \frac{\frac{dQ}{Q} - \frac{dn}{n}}{\frac{dY}{Y} - \frac{dn}{n}}$$

where n is population. As long as we are concerned with necessities it is obvious that per capita income elasticity will always be smaller than the elasticity based on aggregate data.

significant at aggregate level or at the per capita level. In another five commodity groups the coefficient is not significant. Prices seemingly play a more modest role in the consumer demand for nondurable goods.

The importance of the lag in the demand for different commodity groups is presented in Table 3.21. In 7 commodity groups the lag was significant both with aggregate data and with per capita data. In 4 cases the coefficient was statistically significant either with aggregate data or per capita data. In 3 cases the coefficient was not significant.

To conclude, the results of this chapter reveal that real disposable income plays a more important role than relative prices in the consumer demand. The consumer's response in quantity demanded to changes in prices and income is not instantaneous. The significance of the lag and the estimation of long run elasticities using Liviatan's consistent estimation of a distributed lag model, will be the subject matter in the next chapter.

TABLE 3.20

SUMMARY OF THE RELATIVE IMPORTANCE OF INCOME AND PRICES IN DIFFERENT COMMODITY GROUPS

	Commodity Group	Income Agg.	Income Per Capita	Relative Price Agg.	Relative Price Per Capita
1.	Farm foods	√	√	x	√
2.	Purchased foods	√	√	√	√
3.	Meals	√	√	x	x
4.	Tobacco products	√	√	x	x
5.	Alcoholic beverages	√	√	√	√
6.	Men's clothing	√	√	x	x
7.	Women's clothing	√	√	√	√
8.	Piece goods	√	√	√	x
9.	Notions	√	√	√	√
10.	Footwear	√	x	x	x
11.	Household supplies	√	√	√	√
12.	Soap and cleaning supplies	√	√	x	x
13.	Drugs ane cosmetics	√	√	x	√
14.	Newspapers and magazines	√	√	√	√
15.	All nondurable goods	√	√	x	x
16.	All food	√	√	√	√
17.	All nondurable goods excluding food	√	√	x	x

Note: √ corresponding coefficient is significant
x corresponding coefficient is not significant

TABLE 3.21

SIGNIFICANCE OF LAG IN THE DIFFERENT COMMODITY GROUPS

	Commodity Group	Lag is Significant	
		Aggregate	Per Capita
1.	Farm foods	√	√
2.	Purchased foods	√	√
3.	Meals	√	√
4.	Tobacco products	√	√
5.	Alcoholic beverages	√	x
6.	Men's clothing	√	x
7.	Women's clothing	x	x
8.	Piece goods	x	x
9.	Notions	x	√
10.	Footwear	√	x
11.	Household supplies	√	√
12.	Soap & cleaning supplies	x	x
13.	Drugs & cosmetics	√	√
14.	Newspapers & magazines	√	√
15.	All nondurables	√	√
16.	All food	√	x
17.	All nondurables excluding food	√	x

Note: √ lagged value ofthe dependent variable in equations (4) and (8) in Tables (3.3) to (3.19) is significant.
x is not significant.

CHAPTER IV

CONSISTENT ESTIMATION OF DISTRIBUTED LAGS

A distributed lag model of the Koyck type results in the lagged value of the dependent variable as an explanatory variable. Application of ordinary least squares to such a model results in estimates which are not even consistent if there is auto-correlation in the disturbances. This was briefly discussed in Chapter III. The purpose of this chapter is to obtain estimates using Liviatan's method as described in "Consistent Estimation of Distributed Lags".[1,2]

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[1] N. Liviatan, "Consistent Estimation of Distributed Lags", International Economic Review, Vol. 4, No. 1, (January, 1963), pp. 44-52.

[2] The other methods which also yield consistent estimates are due to L.M. Koyck, op. cit.; L.R. Klein, "The Estimation of Distributed Lags", Econometrica, Vol. 26 (October, 1958), pp. 553-565; L.D. Taylor and T.A. Wilson, "Three Pass Least Squares: A Method of Estimating Models with a Lagged Dependent Variable", Review of Economics and Statistics, Vol. 46, No. 4 (1964), pp. 329-346; E.J. Hannan, "The Estimation of Relations Involving Distributed Lags", Econometrica, Vol. 33 (January, 1965), pp. 206-224; T. Amemiya and W. Fuller, "A Comparative Study of Alternative Estimators in a Distributed Lag Model", Econometrica, Vol. 35, No. 3-4 (July-October, 1967), pp. 509-529; and P.J. Dhrymes, "Efficient Estimation of Distributed Lags with Auto-correlated Errors", International Economic Review, Vol. 10, No. 1 (February, 1969), pp. 47-65.

Both the Koyck method and Klein's method assume that the serial correlation coefficient is known in a distributed lag model. Liviatan's model does not need the knowledge of the serial correlation coefficient in the distributed lag specification of the model. The other methods, as proposed by Taylor and Wilson, Hannan, Amemiya and Fuller, and Dhrymes, are computationally more difficult than Liviatan's method. As we have a large sample size we are justified in using Liviatan's method which yields consistent estimates.

The plan of this chapter is as follows: Part I describes Liviatan's method and its properties. Part II is devoted to a discussion of empirical findings. Also included in this section is a comparison of Liviatan's estimates with ordinary least squares estimates. In Part III an overview of the empirical findings of Part II is presented. The chapter concludes by noting that ordinary least squares tend to over estimate the lag in the consumer response to changes in relative prices and real income.

Part I: Liviatan's Method

Liviatan's method is essentially an instrumental variable technique applied to the problem of distributed lags. The method can also be interpreted in terms of Theil's "two stage" least squares.[1] In the model

$$Q_t = \beta_0 + \beta_1 P_t + \beta_2 Y_t + \beta_3 \text{QLAG} + u_t \tag{4.1}$$

we replace QLAG, which is the source of least squares bias, by an asymptotically exogenous substitute QLAG. QLAG is the calculated value of QLAG from a least squares regression of Q_t on P_t, P_{t-1}, Y_t, and Y_{t-1}. QLAG involves deleting the last observation in the Q_t series.

---

[1] H. Theil, Economic Forecasts and Policy (Amsterdam: North Holland Publishing Co., 1958), pp. 223-229.

In symbols, first we run a regression of the type[1]

$$Q_t = \beta_0 + \beta_1 P_t + \beta_2 P_{t-1} + \beta_3 Y_t + \beta_4 Y_{t-1} \qquad (4.2)$$

we obtain $\hat{Q}_t$, the estimated value of Q_t in the regression equation (4.2). Then we delete the last observation to obtain QLAG. We use $\widehat{QLAG}$ in the second stage regression, namely,

$$Q_t = \beta_0 + \beta_1 P_t + \beta_2 Y_t + \beta_3 \widehat{QLAG} \qquad (4.3)$$

The estimates in equation (4.3) are consistent.[2] An additional advantage of this method is that it does not require the disturbances to be homoscedastic. Furthermore no assumption about the autocorrelation scheme of the disturbances is made.

---

[1] One can use more than one lagged value of the explanatory variables as exogeneous variables in the first stage. That is, one can use P_{t-2}, P_{t-3},... etc. and Y_{t-2}, Y_{t-3},... etc. as explanatory variables in equation (4.2). Liviatan suggests that in time series data it is enough to use one lagged value as another explanatory variable. cf., Liviatan, op. cit., p. 48.

[2] The proof follows from the consistency of Theil's two stage least squares estimation method. For proof see C.F. Christ, Econometric Models and Methods (John Wiley, New York, 1966).

Part II: Empirical Findings

A selection of six commodity groups was made to obtain estimates using Liviatan's method. The decision was based on the results obtained in Chapter III. Only if the coefficient of the lagged value of the dependent variable is greater than 0.50[1] is the corresponding commodity group included for a study in this chapter.

This decision gave six commodity groups for a study in this chapter. These were (1) purchased foods; (2) meals; (3) household supplies; (4) drugs and cosmetics; (5) newspapers and magazines; (6) all nondurable goods. Each of these commodity groups revealed a significant lag both with the aggregate data and the per capita data. If the aggregate data revealed a longer lag than the per capita data, the former was used to obtain Liviatan's estimates. Alternatively, if the per capita data revealed a longer lag than the aggregate data, then per capita data were used to obtain Liviatan's estimates. One exception was made to this rule. This was in the case of meals. In the demand function for meals the results in the previous chapter showed that the lagged value of the dependent variable with per capita data was 0.84, while with the aggregate data it was 0.66. Unfortunately neither the price nor income coefficients were

---

[1] If the coefficient of the lagged dependent variable, λ, is 0.50, the implied average lag is one quarter. In general, if the lagged value of the dependent variable is λ, then the implied average lag is $\lambda/1-\lambda$. For a proof of this see Zvi Griliches, *op. cit.*, pp. 18-19.

significant with the per capita data. For this reason, aggregate data were used to obtain Liviatan's estimates in the case of meals. In summary, only for household supplies were per capita data used to obtain Liviatan's estimates. In the remaining five commodity groups the estimates in this chapter are based on aggregate data.

The regression coefficients obtained by Liviatan's method and ordinary least squares estimates are presented on pages 98 to 103. To facilitate comparison, ordinary least squares estimates are presented below the Liviatan's estimates. The absolute value of the t-ratios is presented just below the regression coefficients. The value of R^2, square of the multiple correlation coefficient, is presented both in Liviatan's estimates and ordinary least squares estimates. For each commodity group a table giving the price and income elasticities and average lag based on both the methods are presented. Both short-run and long-run price and income elasticities are presented. Short-run income elasticity means the percentage change in the quantity demanded <u>during the first quarter</u>, for a given percentage change in income. Long-run income elasticity means percentage change in the quantity demanded <u>after the complete adjustment</u> due to a percentage change in income. The "complete adjustment" may take one quarter, two quarters or any number of quarters. These are the same as impact and ultimate effects. In the remainder of this part of the chapter a discussion of the individual commodity groups is given.

Purchased Foods

The results for this commodity group are presented on page 98. We expect this commodity group to reveal inelastic demand with respect to both price and income. Although income elasticity of demand conforms to our expectation, price elasticity appears to be larger than expected. This is true especially with the long-run elasticity.

The interesting feature is that Liviatan's estimates reveal a lag of duration less than half a quarter, while ordinary least squares estimates reveal it to be one and a half quarters. Even though the short-run price and income elasticities are different, the corresponding long-run elasticities are about the same. This is clearly seen in Table 4.1. Liviatan's estimates show that about 67 per cent of the response takes place within one quarter, whereas ordinary least squares reveal only 40 per cent of the adjustment within one quarter.[1] Although the difference is not substantial it cannot be ignored.

---

[1] These figures are derived from Table 4.1. The short-run and income elasticity is 0.51 and the long-run income elasticity is 0.74. As already noted the short-run income elasticity refers to the percentage change in the quantity demanded <u>during the first quarter</u>, for a given percentage change in income. Long-run income elasticity refers to the percentage change in the quantity demanded after the complete adjustment due to a percentage change in income. As 0.51 forms 67 per cent of 0.74 we conclude that 67 percent of the response takes place within one quarter.

Meals

The results for this commodity group are presented on page 99. As the t-ratio in both types of estimates for the relative price coefficient is small we ignore that coefficient. The short-run income elasticity of demand given by Liviatan's technique is 0.18 while it is only 0.12 by ordinary least squares method. While the ordinary least squares method reveals substantial lag, the coefficient obtained by Liviatan's method is not statistically significant. Whether we regard the coefficient of lagged dependent variable using Liviatan's estimation method to be either 0.46 or zero, in either case it is smaller than the coefficient obtained by using ordinary least squares. This implies, again, that ordinary least squares tend to over estimate the implied lag. Unfortunately, neither ordinary least squares estimates nor Liviatan's estimates conform to our prior expectation about the size of income elasticity.[1] We expect the income elasticity of demand to be greater than unity, as restaurant meals is a luxury good.

Household Supplies

The results of this commodity group are presented on page 100. Both relative prices and real income coefficients are statistically significant by both methods. The coeffi-

---

[1] That part of this is due to limitation of the data has been discussed in Chapter III, in the discussion of the results of meals.

cient of the lagged value of the dependent variable in the case of ordinary least squares is twice as large as the corresponding coefficient obtained by Liviatan's method. The short-run price and income elasticities are larger by Liviatan's method than by ordinary least squares method, but the long-run price and income elasticities are larger by ordinary least squares than by Liviatan's method. This simply means that the estimated lag is larger if we accept ordinary least squares estimates. The results of ordinary least squares estimates reveal that only 50 per cent of the adjustment takes place during the first quarter for a given change in relative prices and real income. The results of Liviatan's estimates reveal 80 per cent of adjustment in the quantity demanded during the first quarter, for a given change in the relative prices or real income.

Drugs and Cosmetics

The results of this commodity group are presented on page 101. The difference between the Liviatan's estimates and ordinary least squares estimates is substantial in this commodity group. The short-run price and income elasticity is larger by Liviatna's method than that given by the ordinary least squares method. The opposite is true for long-run elasticities. The average lag is less than half a quarter as revealed by Liviatan's method, while it is more than three quarters in the case of ordinary least squares estimates.

It is important to know that during the first quarter.

about 75 per cent of the adjustment[1] takes place if we accept Liviatan's method, whereas only less than 25 per cent of the adjustment takes place if we accept the ordinary least squares method. This difference is substantial. It is interesting to know that while the long-run income elasticity is approximately the same in both methods, the implied time shape of reaction[2] is different.

Newspapers and Magazines

The results of this commodity group are presented on page 102. The coefficients of relative price, real disposable income and the lagged dependent variable are all statistically significant. Both methods yield a very high value of R^2.

The implied average lag obtained by the ordinary least squares method is larger than the one based on Liviatan's method. Liviatan's estimates show that about 67 per cent of the adjustment takes place during the first quarter. Ordinary least squares results reveal only 37 per cent of the adjustment during the first quarter. Again it should

---

[1] The word "adjustment" is used to mean the adjustment of quantity demanded for a given change in relative prices and real income.

[2] The phrase "time shape of reaction" may be interpreted as the time path of adjustment. Graphically we can interpret it by taking time as domain and the percentage of adjustment as range.

be noted that although the long-run price and income elasticities are approximately the same in both methods, the time shape of reaction is different. The results of this commodity group conform to our prior expectations that both price and income elasticities of demand be less than unity.

All Nondurable Goods

The results of this commodity group are presented on page 103. The coefficients of real disposable income and the lagged value of the dependent variable are statistically significant by both methods. Further, both methods gave fairly high values of R^2. The relative price coefficient is not significant in either of the two methdos, although it has the expected sign by Liviatan's method.

Again, we find that, whereas the long-run income elasticity of demand is approximately the same in both the methods, the time shape of reaction is different in the two methods. More than 50 per cent of the judgment would take place during the first quarter, by Liviatan's method; whereas only 30 per cent of the adjustment would take place during the first quarter if we accept the ordinary least squares method. The average lag implied by ordinary least squares is approximately three times as large as the average lag implied by Liviatan's method.

Part III: An Overview of Empirical Findings

The results for the six commodity groups revealed very high values for R^2, both by the Liviatan technique and the ordinary least squares method. The coefficient of income is statistically significant in all cases. The coefficient of relative price has the expected sign and is statistically significant in four out of the six commodity groups. The coefficient of the lagged value of the dependent variable has the expected sign in all the cases studied. It is statistically significant in five commodity groups.

In all the six cases, Liviatan's estimates gave the coefficient of the lagged value of the dependent variable smaller than the one obtained by the ordinary lease square method. In all six cases, the short-run price and income elasticities were larger by Liviatan's method than by the ordinary least squares method. Excluding the case of meals, the long-run income elasticity was approximately the same, by both methods, in the remaining five cases. The long-run price elasticity was approximately the same by the two methods in the case of three commodity groups. These were purchased foods, household supplies, and newspapers and magazines. The long-run price elasticity was significantly different by the two methods in the case of drugs and cosmetics.

With one or two exceptions, we may conclude that while the short-run price and income elasticities are larger in

the case of Liviatan's procedure, the long-run price and income elasticities are approximately the same by the two methods. This simply means that the two methods give two different time shapes of reaction for a given change in both the relative prices and real income. Ordinary least squares tend to overestimate the lag.[1]

In conclusion, we note that use of Liviatan's estimation technique gave results which are different from those obtained by the ordinary least squares method. Liviatan's estimation technique reveals virtual nonexistence of the lag or a very small extent of it. Ordinary least squares results have shown the lag to be substantially larger than the one given by Liviatan's technique. The time shape of the reaction yielded by the two methods is also different. The results of this chapter have an important bearing on the econometric studies involving distributed lag models. By applying ordinary least squares one erroneously concludes that there is a considerably lower rate of adjustment. After applying Liviatan's technique one may have to change the conclusions.

---

[1] We have seen in Chapter III that if the serial correlation in the disturbances is positive ordinary least squares tend to overestimate the implied average lag. This point is clarified in Zvi Griliches, "A Note on Serial Correlation Bias in Estimates of Distributed Lags", Econometrica, Vol. 29, No. 1 (January, 1961), pp. 65-73.

Purchased Food

$$Q = \begin{matrix} 2.780 - \underset{(6.47)}{0.07} \log S_1 + \underset{(2.77)}{0.05} \log S_2 - \underset{(3.46)}{0.06} \log S_3 \\ 1.584 - \underset{(7.42)}{0.08} \log S_1 + \underset{(4.86)}{0.08} \log S_2 - \underset{(1.87)}{0.03} \log S_3 \\ - \underset{(4.6)}{1.19} \log P + \underset{(5.75)}{0.51} \log Y + \underset{(2.53)}{0.31} \log \widehat{QLAG} \\ - \underset{(2.82)}{0.72} \log P + \underset{(3.45)}{0.30} \log Y + \underset{(5.42)}{0.60} \log QLAG \end{matrix} \qquad (4.2.1)$$

R^2 (Based on Liviatan's estimates) = 0.98

R^2 (Based on ordinary least squares) = 0.98

TABLE 4.1 COMPARISON OF ELASTICITIES AND AVERAGE LAG BY THE LIVIATAN'S AND ORDINARY LEAST SQUARES TECHNIQUES - PURCHASED FOOD.

	Liviatan's Method	Ordinary Least Squares
Short run price elasticity	-1.2	-0.72
Long run price elasticity	-1.7	-1.8
Short run income elasticity	0.51	0.30
Long run income elasticity	0.74	0.75
Average lag in quarters	0.45	1.5

Meals

$$
\begin{array}{llll}
Q_t = 1.876 & - \underset{(0.67)}{0.04} \log S_1 & + \underset{(0.91)}{0.12} \log S_2 & + \underset{(1.57)}{0.16} \log S_3 \\
 1.10 & - \underset{(0.84)}{0.02} \log S_1 & + \underset{(4.62)}{0.17} \log S_2 & + \underset{(6.46)}{0.19} \log S_3 \\
& + \underset{(0.48)}{0.20} \log P & + \underset{(1.08)}{0.18} \log Y & + \underset{(0.86)}{0.46} \log \widehat{QLAG} \\
& - \underset{(0.64)}{0.20} \log P & + \underset{(2.47)}{0.12} \log Y & + \underset{(4.53)}{0.66} \log QLAG
\end{array}
\tag{4.2.2}
$$

R^2 (Based on Liviatan's estimates) = 0.90

R^2 (Based on ordinary least squares estimates) = 0.93

TABLE 4.2 INCOME ELASTICITIES OBTAINED BY THE LIVIATAN'S AND ORDINARY LEAST SQUARES METHODS - MEALS

	Liviatan's Method	Ordinary Least Squares
Short run income elasticity	0.18	0.12
Long run income elasticity	0.18 or 0.33	0.36

Household Supplies

$$
\begin{array}{llllll}
\text{Log } q = & 0.12 - \underset{(30.09)}{0.73 \log S} & + \underset{(0.20)}{0.02 \log S_2} & - \underset{(8.05)}{0.18 \log S_3} & - \underset{(2.39)}{0.02\, t} \\
 & 0.05 - \underset{(30.50)}{0.76 \log S_1} & + \underset{(1.59)}{0.17 \log S_2} & - \underset{(7.31)}{1.65 \log S_3} & - \underset{(1.77)}{0.05\, t} \\
 & \quad - \underset{(4.3)}{1.8 \log P} & + \underset{(3.88)}{0.39 \log y} & + \underset{(1.43)}{0.23 \log \widehat{q\ \text{LAG}}} & \\
 & & & & (4.2.3) \\
 & \quad - \underset{(2.83)}{1.25 \log P} & + \underset{(3.20)}{0.31 \log y} & + \underset{(2.74)}{0.48 \log q\ \text{LAG}} &
\end{array}
$$

R^2 (Based on Liviatan's estimates) = 0.99

R^2 (Based on ordinary least squares estimates) = 0.99

TABLE 4.3 PRICE AND INCOME ELASTICITIES AND AVERAGE LAG BY LIVIATAN'S AND ORDINARY LEAST SQUARES METHODS - HOUSEHOLD SUPPLIES

	Liviatan's Method	Ordinary Least Squares
Short run price elasticity	-1.8	-1.3
Long run price elasticity	-2.2	-2.5
Short run incomeelasticity	0.39	0.31
Long run income elasticity	0.51	0.60
Average lag in quarters	0.30	0.92

Drugs and Cosmetics

$$\underset{}{\text{Log } Q} = 1.28 - \underset{(5.12)}{0.25} \log S_1 - \underset{(19.3)}{0.22} \log S_2 - \underset{(14.01)}{0.32} \log S_3$$

$$0.51 - \underset{(11.15)}{0.39} \log S_1 - \underset{(23.45)}{0.23} \log S_2 - \underset{(14.06)}{0.27} \log S_3 \qquad (4.2.4)$$

$$- \underset{(1.85)}{0.33} \log P + \underset{(4.28)}{0.54} \log Y + \underset{(1.54)}{0.27} \log QLAG$$

$$- \underset{(1.76)}{0.25} \log P + \underset{(1.74)}{0.17} \log Y + \underset{(6.38)}{0.77} \log QLAG$$

R^2 (Based on Liviatan's procedure) = 0.98

R^2 (Based on ordinary least squares) = 0.98

TABLE 4.4 COMPARISON OF ELASTICITIES AND AVERAGE LAG BY THE LIVIATAN'S AND ORDINARY LEAST SQUARES TECHNIQUES- DRUGS AND COSMETICS

	Liviatan's Method	Ordinary Least Squares
Short run price elasticity	-0.33	-0.25
Long run price elasticity	-0.45	-1.1
Short run income elasticity	0.54	0.17
Long run income elasticity	0.73	0.74
Average lag in quarters	0.37	3.4

Newspapers and Magazines

$$Q = \underset{}{0.84} - \underset{(11.96)}{1.00} \log S_1 - \underset{(39.12)}{0.83} \log S_2 - \underset{(14.37)}{0.65} \log S_3$$

$$0.58 - \underset{(13.62)}{1.20} \log S_1 - \underset{(35.50)}{0.79} \log S_2 - \underset{(11.78)}{0.56} \log S_3$$

$$- \underset{(4.54)}{0.60} \log P + \underset{(5.44)}{0.54} \log Y + \underset{(2.99)}{0.34} \log \widehat{QLAG} \qquad (4.2.5)$$

$$- \underset{(2.61)}{0.33} \log P + \underset{(3.57)}{0.34} \log Y + \underset{(5.00)}{0.62} \log QLAG$$

R^2 (Based on Liviatan's method) = 1.00 (Actual value is 0.996)

R^2 (Based on ordinary least squares) = 1.00 (Actual value is 0.996)

TABLE 4.5 PRICE AND INCOME ELASTICITIES AND AVERAGE LAG BY LIVIATAN'S AND ORDINARY LEAST SQUARES METHOD - NEWSPAPERS AND MAGAZINES

	Liviatan's Method	Ordinary Least Squares
Short run price elasticity	-0.60	-0.33
Long run price elasticity	-0.91	-0.87
Short run income elasticity	0.54	0.34
Long run income elasticity	0.82	0.89
Average lag	0.52	1.6

All Nondurable Goods

$$Q = 2.52 - \underset{(10.39)}{0.37} \log S_1 - \underset{(13.67)}{0.19} \log S_2 - \underset{(12.16)}{0.27} \log S_3$$

$$- \underset{(0.21)}{0.04} \log P + \underset{(4.20)}{0.43} \log Y + \underset{(3.51)}{0.46} \log QLAG$$

$$1.66 - \underset{(13.39)}{0.43} \log S_1 - \underset{(12.47)}{0.17} \log S_2 - \underset{(10.8)}{0.24} \log S_3$$

$$+ \underset{(0.13)}{0.03} \log P + \underset{(2.66)}{0.25} \log Y + \underset{(5.83)}{0.70} \log QLAG \qquad (4.2.6)$$

R^2 (Based on Liviatan's estimates) = 0.99

R^2 (Based on ordinary least squares estimates) = 0.98

TABLE 4.6 COMPARISON OF ELASTICITIES AND AVERAGE LAG BY THE LIVIATAN'S AND THE ORDINARY LEAST SQUARES METHODS - ALL NONDURABLE GOODS

	Liviatan's Method	Ordinary Least Squares
Short run price elasticity	Not Significant	Not Significant
Long run price elasticity	-	-
Short run income elasticity	0.43	0.25
Long run income elasticity	0.80	0.83
Average lag in quarters	0.85	2.3

CHAPTER V

ESTIMATION OF SEEMINGLY UNRELATED REGRESSIONS

In this chapter the demand for different consumer nondurable goods is reviewed as an interrelated decision. For example, the demand for purchased food and meals is an interrelated decision. The demand for men's clothing and women's clothing is an interrelated decision, and so on. An estimation procedure for such an interrelated set of decisions has been suggested by Zellner.[1] This method with some modifications is followed in this chapter. Using Liviatan's method it was found, in Chapter IV, that the lag is not important in the demand for nondurable goods. In five of the six commodity groups the average lag was found to be less than or equal to half a quarter. For this reason a simple model (that is excluding the lagged dependent variable as an explanatory variable) was used to estimate the elasticities of demand. Also there is no method of estimation of Zellner's technique available in the literature which takes into account simultaneously the serial-correlation in the disturbances and the distributed lag model.[2]

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[1] Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regre-sions and Tests for Aggregation Bias", The Journal of the American Statistical Association, Vol. 57, (Junem 1962), pp. 348-358.

[2] The paper by Jan Kmenta and Roy F. Gilbert, "Small Sample Properties of Alternative Estimators of Seemingly Unrelated Regressions", The Journal of American Statistical Association, Vol. 63, (December, 1968), pp. 1180-1200, considers separately the problems of autocorrelation and lagged variables but not simultaneously.

The plan of this chapter is as follows: Part I explains the model and the method of estimation. Part II gives the empirical findings along with a comparison with ordinary least squares estimates. Part III presents the results adopted by alternative pairing of the commodity groups. Part IV is devoted to a comparison of the estimates obtained in this chapter with the estimates obtained for the U.S. and U.K. economies.

Part I: The Method of Estimation

The method of estimation followed in this chapter is basically due to Zellner.[1] This method of estimating the parameters of a set of regression equations involves application of Aitken's generalised least squares to the whole system of equations. It is found that the regression coefficient estimators so obtained are at least asymptotically more efficient than those obtained by an equation-by-equation application of least squares. The method is described in more detail as follows:

The method is given in detail in the case of demand for two commodities:

$$\left.\begin{aligned} q_1 &= \beta_{10} + \beta_{11} S_1 + \beta_{12} S_2 + \beta_{13} S_3 + \beta_{14} y + \beta_{15} P_1 + u_1 \\ q_2 &= \beta_{20} + \beta_{21} S_1 + \beta_{22} S_2 + \beta_{23} S_3 + \beta_{24} y + \beta_{25} P_2 + u_2 \end{aligned}\right\} \quad (5.0)$$

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[1] A. Zellner, <u>op</u>. <u>cit</u>.

where q_1 and q_2 are the demand for two related commodity groups. The β's are the regression coefficients, y is the real disposable income, the P's are the relative or the deflated prices, and the u's are disturbance terms. Denoting the sets of explanatory variables X_1 and X_2 respectively, we can write (5.0) as

$$\left.\begin{aligned} q_1 &= X_1 \beta_1 + u_1 \\ q_2 &= X_2 \beta_2 + u_2 \end{aligned}\right\} \tag{5.1}$$

q's are vectors of size T x 1, X's are matrices of size T x 6 and β's are vectors of size 6 x 1 and the disturbance are vectors of size T x 1.

The system (5.1) may be written as

$$\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} \tag{5.2}$$

or

$$q = [X] \; \beta + u \tag{5.3}$$

where

$$q \equiv \begin{bmatrix} q_1 \\ \\ q_2 \end{bmatrix}, \quad X \equiv \begin{bmatrix} X_1 & 0 \\ \\ 0 & X_2 \end{bmatrix}, \quad \beta \equiv \begin{bmatrix} \beta_1 \\ \\ \beta_2 \end{bmatrix}, \quad u \equiv \begin{bmatrix} u_1 \\ \\ u_2 \end{bmatrix}.$$

The (2T x 1) disturbance vector in (5.3) is assumed to have the following variance-covariance matrix:[1]

$$\Sigma = V(u) = \begin{bmatrix} \sigma_{11}\, I & \sigma_{12}\, I \\ \\ \sigma_{21}\, I & \sigma_{22}\, I \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \\ \sigma_{21} & \sigma_{22} \end{bmatrix} \otimes I \qquad (5.4)$$

$$= \Sigma_c \otimes I$$

Where I is a unit matrix of size T x T and

$$\left.\begin{aligned} \sigma_{11} &= E(u_{1t}^2) \\ \sigma_{12} &= E(u_{1t}u_{2t}) \\ \sigma_{21} &= E(u_{2t}u_{1t}) \\ \sigma_{22} &= E(u_{2t}^2) \end{aligned}\right\} \quad t = 1,2,\ldots,T$$

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[1] This assumption has been relaxed by Parks to take into account the serial correlation in the disturbances. See R.W. Parks, "Efficient Estimation of a System of Regression Equations when Disturbances are Both Serially and Contemporaneously Correlated", The Journal of American Statistical Association, Vol. 62 (December, 1967), pp. 500-509.

σ_{11} is the variance of the disturbance of the first equation, σ_{12} is the covariance of the disturbances of the first and second equations, σ_{21} is the same as σ_{12}, and σ_{22} is the variance of the disturbance of the second equation.

We now regard equation (5.3) as a single-equation regression model and apply Aitken's generalised least squares. That is, we premultiply both sides of (5.3) by a matrix H which is such that $E(H\ u\ u'\ H') = H \sum H' = I$. In terms of the transformed variables, the original variables premultiplied by H, the system now satisfies the usual assumptions of the least squares model. Thus application of least squares will yield, as is well known, a best linear unbiased estimator, which is

$$b^* = (X'\ H'\ H\ X)^{-1} .\ X'\ H'\ H\ y = (X' \textstyle\sum^{-1} X)^{-1} .\ X' \textstyle\sum^{-1} y \qquad (5.5)$$

In constructing this estimator we need the inverse of $\sum$ which is given by

$$\textstyle\sum^{-1} = V^{-1}(u) = \begin{bmatrix} \sigma^{11} . I & \sigma^{12}\ I \\ & \\ \sigma^{21} . I & \sigma^{22}\ I \end{bmatrix} = \textstyle\sum_c^{-1} \otimes I \qquad (5.6)$$

Then the Aitken estimator of the coefficient vector, given in (5.5) is

$$b^* = \begin{bmatrix} b_1^* \\ \\ b_2^* \end{bmatrix} = \begin{bmatrix} \sigma^{11} \cdot (X_1' X_1) & \sigma^{12} \cdot (X_1' X_2) \\ \\ \sigma^{21} \cdot (X_2' X_1) & \sigma^{22} \cdot (X_2' X_2) \end{bmatrix}^{-1} \begin{bmatrix} \sigma^{11} X_1' q_1 + \sigma^{12} X'_1 q_2 \\ \\ \sigma^{21} X_2' q_1 + \sigma^{22} X_2' q_2 \end{bmatrix} \tag{5.7}$$

and the variance-covariance matrix of the estimator b^* is easily seen to be $(X' \Sigma^{-1} X)^{-1}$, or

$$V(b^*) = \begin{bmatrix} \sigma^{11} \cdot X_1' X_1 & \sigma^{12} \cdot X_1' X_2 \\ \\ \sigma^{21} \cdot X_2' X_1 & \sigma^{22} \cdot X_2' X_2 \end{bmatrix}^{-1} \tag{5.8}$$

It is to be noted that (5.7) is identical with estimators provided by single-equation least squares if the disturbance terms have a diagonal variance-covariance matrix, i.e., if $\sigma_{12} = \sigma_{21} = 0$. Also, if X_1 equals X_2, equation (5.7) "collapses" to yield single-equation least squares estimators even if disturbance terms in different equations are correlated ($\sigma_{12} \neq 0$). When X_1 and X_2 are different, and when the disturbance terms in different equations are correlated, the estimator in (5.7) will differ from the single-equation least squares estimators.

If Σ is unknown, as it usually is, it is impossible to

use (5.7) in practice. Zellner,[1] in his method, proposed an estimate of the $\sum$ matrix. This estimate is

$$\left.\begin{aligned}
\hat{\sigma}_{11} &= S_{11} = \frac{(q_1 - X_1\hat{\beta}_1)'\,(q_1 - X_1\hat{\beta}_1)}{(T - \ell)} = \frac{\hat{u}_1'\,\hat{u}_1}{(T - \ell)} \\
\hat{\sigma}_{12} &= S_{12} = \frac{(q_1 - X_1\hat{\beta}_1)'\,(q_2 - X_2\hat{\beta}_2)}{(T - \ell)} = \frac{(\hat{u}_1'\,\hat{u}_2)}{(T - \ell)} \\
\hat{\sigma}_{21} &= S_{21} = \frac{(q_2 - X_2\hat{\beta}_2)'\,(q_1 - X_1\hat{\beta}_1)}{(T - \ell)} = \frac{\hat{u}_2'\,\hat{u}_1}{(T - \ell)} \\
\hat{\sigma}_{22} &= S_{22} = \frac{(q_2 - X_2\hat{\beta}_2)'\,(q_2 - X_2\hat{\beta}_2)}{(T - \ell)} = \frac{\hat{u}_2'\,\hat{u}_2}{(T - \ell)}
\end{aligned}\right\} \qquad (5.9)$$

where $\hat{\beta}_1$ and $\hat{\beta}_2$ represent the usual single-equation least squares estimators, $(X_1'\,X_1)^{-1}\,X_1'\,q_1$ and $(X_2'\,X_2)^{-1}\,X_2'\,q_2$ respectively. 'ℓ' is the number of explanatory variables: in our example it is 6. Given that we have the estimate $\begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$, we can obtain by inverting the matrix $\begin{bmatrix} S^{11} & S^{12} \\ S^{21} & S^{22} \end{bmatrix}$, the elements of which are employed to form the estimator

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[1] A. Zellner, op. cit., pp. 352-354.

$$b = \begin{bmatrix} b_1 \\ \\ b_2 \end{bmatrix} = \begin{bmatrix} s^{11} X_1' X_1 & s^{12} X_1' X_2 \\ \\ s^{12} X_2' X_1 & s^{22} X_2' X_2 \end{bmatrix}^{-1} \begin{bmatrix} s^{11} X_1' q_1 + s^{12} X_1' q_2 \\ \\ s^{21} X_2' q_1 + s^{22} X_2' q_2 \end{bmatrix} \tag{5.10}$$

It has been shown by Zellner[1] that $b = b* + O(T^{-1})$, that $T^{\frac{1}{2}}(b - \beta)$ and $T^{\frac{1}{2}}(b* - \beta)$ have the same asymptotic normal distribution, and that the moment matrix of b is:

$$V(b) = \begin{bmatrix} s^{11} X_1' X_1 & s^{12} X_1' X_2 \\ \\ s^{21} X_2' X_1 & s^{22} X_2' X_2 \end{bmatrix} + o(T^{-1}) \tag{5.11}$$

where $O(T^{-1})$ denotes a quantity which is of the order T^{-1} in probability and $o(T^{-1})$ denotes terms of higher order of smallness than T^{-1}.

The estimation procedure presented above has been improved by Parks.[2] There are many situations, especially in the estimation of demand functions, where the random disturbances of a system of regression equations may exhibit both contemporaneous

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[1] A. Zellner, Ibid., pp. 352-354.

[2] Richard W. Parks, op. cit., pp. 500-509.

and serial correlation. Taking into account both types of correlation, Parks has suggested a slightly modified version of Zellner's method.

Parks assumes an auto-regressive scheme of the type

$$u_t = \rho u_{t-1} + V_t \ .$$

Parks' suggestion is that if the disturbances are correlated, we make an auto-regressive transformation; i.e., multiply both the dependent and explanatory variables by a matrix (T - 1) x T given by[1]

$$\begin{bmatrix} -\rho & 1 & 0 & 0 & 0 & \cdots & \cdots & 0 \\ 0 & -\rho & 1 & 0 & 0 & \cdots & \cdots & 0 \\ 0 & 0 & -\rho & 1 & 0 & \cdots & \cdots & 0 \\ 0 & 0 & 0 & -\rho & 1 & \cdots & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & 0 & 0 & -\rho & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\rho & 1 \end{bmatrix}$$

and then apply Zellner's technique to the system of the transformed equations. Parks has also shown that in the presence of autocorrelation his estimation procedure is asymptotically more efficient than the estimator developed by Zellner. The

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[1] Parks suggests both this procedure and a somewhat more complicated transformation matrix which has the advantage of not losing one observation.

estimator developed by Parks is consistent and has the same asymptotic normal distribution as the Aitken estimator which assumes the covariance matrix to be known. An APL program has been written for Parks' method of estimation. This is presented in Appendix I.

Part II: Empirical Findings

Ideally, one can obtain asymptotically more efficient estimators by taking into account all the fourteen commodity groups; that is, considering the demand for all the fourteen commodities as one interrelated set of decisions. But this procedure exhibits a serious computation problem. To get the estimates we will need to invert a matrix of size 84 x 84. As this problem is difficult to solve an alternative grouping procedure has been adopted. This procedure involves taking two commodities at a time so that we have in all seven commodity groups:

Group I

1. Purchased foods
2. Meals

Group II

1. Tobacco products
2. Alcoholic beverages

Group III

1. Men's clothing
2. Women's clothing

Group IV

1. Piece goods
2. Notions

Group V

1. Household supplies
2. Soap and cleaning supplies

Group VI

1. Drugs and cosmetics
2. Newspapers and magazines

Group VIII

1. All food
2. All nondurable goods excluding food

The criteria adopted for the above grouping is to place relatively homogenous goods into one group. This problem can be thought of as incorporation of prior information into the estimation procedure. For example, we know that there is a good deal of interrelation in the demand for purchased food and meals. One has to eat at home, which comes under the category of 'purchased food', or eat at a restaurant, which comes under 'meals'. This is our prior knowledge. We incorporate this prior knowledge into the estimation procedure by combining purchased food and meals into one group. We then estimate the regression coefficients simultaneously. There is a good deal of interrelation in the demand for household supplies and soap and cleaning supplies. For this reason these two are included in one group. As piece goods and notions are complementary goods, they are included in one group. The inter-

relation between the demand for the commodity groups included in groups II (tobacco products and alcoholic beverages), III (men's and women's clothing), and VI (drugs and cosmetics and newspapers and magazines) is not so clear. For this reason these have been tentatively grouped as described above. Part III of this chapter presents the differences in the elasticities of demand as a result of differences in pairing adopted.

The serial correlation coefficients of the different commodity groups based on the ordinary least squares method are presented on page 117. The results for these seven commodity groups are presented on pages 118 to 131. For each commodity group both the results based on Parks' method of estimation and on the ordinary least squares method are presented. The regression coefficients based on ordinary least squares are presented <u>below</u> the regression coefficient based on Parks' method. In each case the t-ratios are presented in parentheses. To evaluate the goodness of fit based on Parks' estimate "R^{*2}" has been computed[1] as

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[1] This definition of R^{*2} is similar to that of R^2. We know that R^2 in ordinary least squares is given by $R^2 = \frac{\hat{\beta} X'Y}{Y'Y}$ see J. Johnston, <u>Econometric Methods</u> (McGraw-Hill, New York, 1963), p. 115. In the definition of R^{*2} we simply replace $\hat{\beta}$ by the coefficients obtained by Parks' method. This is an arbitrary measure of the goodness of fit. The properties of R^{*2} are not known.

$$R^{*2} = \frac{\hat{\beta}' X' q}{q' q}$$

where $\hat{\beta}'$ is the transpose of the vector of the estimated regression coefficients by Parks' method, X' is the transpose of the matrix of the explanatory variables and q the vector of the dependent variable.

For each of the seven commodity groups price and income elasticities of demand based on both methods are presented on pages 118 to 131. In what follows, a discussion of the results within different commodity groups is given.

Group I - Purchased Food and Meals

The results within this group are presented on page 118. The regression coefficients based on both methods in the case of purchased food are approximately the same. The income elasticity of demand for purchased food is about 0.5. The price elasticity is around -1.2. These results are in conformity with our prior expectation.

The results for meals are considerably different. The income elasticity based on Parks' method is not significant. Unfortunately, the income elasticity based on ordinary least squares method has a negative sign. The price elasticity based on Parks' method is around 0.7, has the expected sign and statistically significant. This coefficient, based on ordinary least squares, has the wrong sign and is not statistically significant.

TABLE 5.1 THE SERIAL CORRELATION COEFFICIENTS USED IN OBTAINING ESTIMATES BASED ON PARKS' METHOD

Commodity Group	Serial Correlation Coefficient
GROUP I	
Purchased foods	0.000
Meals	0.755
GROUP II	
Tobacco products	0.345
Alcoholic beverages	0.000
GROUP III	
Men's clothing	0.000
Women's clothing	0.000
GROUP IV	
Piece goods	0.285
Notions	0.535
GROUP V	
Household supplies	0.545
Soap and cleaning supplies	-0.245
GROUP VI	
Drugs and cosmetics	0.265
Newspapers and magazines	0.270
GROUP VII	
All food	0.000
All nondurable goods excluding food	0.000

Group I: Purchased Food and Meals

Purchased Food

$$\log q = 3.60 - \underset{(7.64)}{.07} \log S_1 + \underset{(0.83)}{0.008} \log S_2 - \underset{(6.11)}{0.07} \log S_3$$

$$3.61 - \underset{(7.48)}{.08} \log S_1 + \underset{(.63)}{0.006} \log S_2 - \underset{(6.14)}{0.07} \log S_3$$

$$+ \underset{(13.29)}{0.50} \log y - \underset{(5.48)}{1.20} \log P$$

$$+ \underset{(13.28)}{0.50} \log y - \underset{(5.35)}{1.15} \log P$$

R^{*2} (Based on Parks' method) = 0.99998

R^2 (Based on ordinary least squares) = 0.91910

(continued on page 119)

Meals

$$\log q = +.47 - \underset{(9.20)}{.11} \log S_1 + \underset{(.721)}{.008} \log S_2 + \underset{(5.80)}{.12} \log S_3 + \underset{(.63)}{.07} \log y$$

$$2.28 - \underset{(4.79)}{0.13} \log S_1 + \underset{(.47)}{0.01} \log S_2 + \underset{(5.47)}{.17} \log S_3 - \underset{(2.21)}{0.22} \log y$$

$$- \underset{(1.73)}{.69} \log P$$

$$+ \underset{(0.93)}{0.54} \log P$$

R^{*2} (Based on Parks' method) = .9986

R^2 (Based on ordinary least squares) = 0.7398

TABLE 5.2 PRICE AND INCOME ELASTICITIES BY PARKS' AND ORDINARY LEAST SQUARES METHOD - PURCHASED FOOD AND MEALS

	Purchased Food		Meals		
	Parks'	O.L.S.	Parks'	O.L.S.	Transformed Regression-O.L.S.
Income Elasticity	.50	.50	N.S.	-.22	0.28
Price Elasticity	-1.20	-1.15	-0.69	N.S.	N.S.

Group II: Tobacco Products and Alcoholic Beverages

Tobacco Products

$$\log q = \underset{}{1.23} - \underset{(7.45)}{0.27} \log S_1 - \underset{(2.81)}{0.10} \log S_2 - \underset{(3.76)}{0.18} \log S_3$$

$$1.602 - \underset{(5.34)}{0.25} \log S_1 - \underset{(2.71)}{0.12} \log S_2 - \underset{(4.35)}{0.22} \log S_3$$

$$+ \underset{(1.81)}{0.36} \log y - \underset{(.17)}{0.12} \log P$$

$$+ \underset{(3.68)}{0.58} \log y - \underset{(0.56)}{0.31} \log P$$

R^{*2} (Based on Parks' method) = 0.9986

R^2 (Based on ordinary least squares) = 0.6324

(continued on page 121)

Alcoholic Beverages

$$\log q = 1.99 - \underset{(30.13)}{.58} \log S_1 - \underset{(15.53)}{0.29} \log S_2 - \underset{(14.01)}{.30} \log S_3$$

$$1.970 - \underset{(29.28)}{.58} \log S_1 - \underset{(15.83)}{.29} \log S_2 - \underset{(13.83)}{0.30} \log S_3$$

$$+ \underset{(8.41)}{0.58} \log y - \underset{(1.01)}{0.713} \log P$$

$$\underset{(8.32)}{0.59} \log y - \underset{(1.67)}{1.11} \log P$$

R^{*2} (Based on Parks' method) = 0.99989

R^2 (Based on ordinary least squares) = 0.97386

TABLE 5.3 PRICE AND INCOME ELASTICITIES OF DEMAND BY PARKS' AND ORDINARY LEAST SQUARES METHODS - TOBACCO PRODUCTS AND ALCOHOLIC BEVERAGES

	Tobacco Products		Alcoholic Beverages	
	Parks'	O.L.S.	Parks'	O.L.S.
Income Elasticity	0.36	0.58	0.58	0.59
Price Elasticity	N.S.	N.S.	N.S.	-1.11

Group III: Men's and Women's Clothing

Men's Clothing

$$\log q = 1.65 - \underset{(40.07)}{0.83} \log S_1 - \underset{(29.45)}{.56} \log S_2 - \underset{(36.39)}{.81} \log S_3 + \underset{(8.04)}{0.55} \log y$$

$$1.65 - \underset{(38.97)}{0.82} \log S_1 - \underset{(28.95)}{0.56} \log S_2 - \underset{(35.73)}{0.81} \log S_3 + \underset{(8.01)}{0.56} \log y$$

$$+ \underset{(.20)}{0.06} \log P$$

$$+ \underset{(1.09)}{0.39} \log P$$

R^{*2} (Based on Parks' method) = 0.99980

R^2 (Based on ordinary least squares) = 0.98632

(continued on page 123)

Women's Clothing

$$\log q = \underset{(48.81)}{2.53 - 0.74} \log S_1 - \underset{(30.14)}{0.42} \log S_2 - \underset{(36.71)}{0.59} \log S_3$$

$$\underset{(47.32)}{2.51 - 0.74} \log S_1 - \underset{(29.52)}{0.42} \log S_2 - \underset{(36.12)}{0.59} \log S_3$$

$$+ \underset{(5.90)}{0.30} \log y - \underset{(5.84)}{0.61} \log P$$

$$+ \underset{(5.98)}{0.31} \log y - \underset{(4.32)}{0.52} \log P$$

R^{*2} (Based on Parks' method) = 0.99995

R^2 (Based on ordinary least squares) = 0.98923

TABLE 5.4 PRICE AND INCOME ELASTICITIES OF DEMAND BY PARKS' AND ORDINARY LEAST SQUARES METHODS - MEN'S AND WOMEN'S CLOTHING

	Men's Clothing		Women's Clothing	
	Parks'	O.L.S.	Parks'	O.L.S.
Income Elasticity	0.55	0.56	0.30	0.31
Price Elasticity	N.S.	N.S.	-0.61	-0.52

Group IV: Piece Goods and Notions

Piece Goods

$$\log q = \underset{}{.35} + \underset{(15.59)}{0.32} \log S_1 - \underset{(5.24)}{0.11} \log S_2 - \underset{(3.73)}{0.10} \log S_3$$

$$.55 + \underset{(13.08)}{0.32} \log S_1 - \underset{(4.40)}{0.10} \log S_2 - \underset{(3.28)}{0.09} \log S_3$$

$$- \underset{(3.01)}{0.32} \log y - \underset{(1.23)}{0.57} \log P$$

$$- \underset{(4.20)}{0.36} \log y - \underset{(0.25)}{0.08} \log P$$

R^{*2} (Based on Parks' method) = 0.96801

R^2 (Based on ordinary least squares) = 0.94302

(continued on page 125)

Notions

$$\log q = 0.47 - \underset{(30.74)}{0.58} \log S_1 - \underset{(32.03)}{0.60} \log S_2 - \underset{(13.72)}{0.41} \log S_3$$

$$1.38 - \underset{(20.73)}{0.60} \log S_1 - \underset{(21.87)}{0.59} \log S_2 - \underset{(10.91)}{0.35} \log S_3$$

$$- \underset{(6.36)}{0.86} \log y - \underset{(4.04)}{2.48} \log P$$

$$- \underset{(11.53)}{1.15} \log y - \underset{(4.33)}{1.70} \log P$$

R^{*2} (Based on Parks' methods) = 0.99538

R^2 (Based on ordinary least squares) = 0.95815

TABLE 5.5 PRICE AND INCOME ELASTICITIES OF DEMAND BY PARKS' AND ORDINARY LEAST SQUARES METHODS - PIECE GOODS AND NOTIONS

	Piece Goods		Notions		
	Parks'	O.L.S.	Parks'	O.L.S.	Transformed Regression-O.L.S.
Income Elasticity	-0.32	-0.36	-0.864	-1.145	-0.87
Price Elasticity	N.S.	N.S.	-2.480	-1.696	-2.52

Group V: Household Supplies and Soap and Cleaning Supplies

Household Supplies

$$\log q = \underset{}{0.15} - \underset{(59.21)}{0.71} \log S_1 - \underset{(11.48)}{0.13} \log S_2 - \underset{(7.95)}{0.18} \log S_3$$

$$0.30 - \underset{(39.94)}{0.71} \log S_1 - \underset{(7.90)}{0.13} \log S_2 - \underset{(7.44)}{0.19} \log S_3$$

$$+ \underset{(2.75)}{0.29} \log y - \underset{(7.33)}{2.42} \log P$$

$$+ \underset{(3.26)}{0.33} \log y - \underset{(10.19)}{2.85} \log P$$

R^{*2} (Based on Parks' method) = 0.99724

R^2 (Based on ordinary least squares) = 0.98747

(continued on page 127)

Soap and Cleaning Supplies

$$\log q = -0.67 + \underset{(3.28)}{0.08} \log S_1 + \underset{(5.35)}{0.11} \log S_2 - \underset{(2.53)}{0.07} \log S_3$$

$$- 0.51 + \underset{(3.53)}{0.08} \log S_1 + \underset{(5.08)}{0.11} \log S_2 - \underset{(2.46)}{0.07} \log S_3$$

$$+ \underset{(10.00)}{0.66} \log y - \underset{(.65)}{0.27} \log P$$

$$+ \underset{(7.92)}{0.64} \log y - \underset{(0.44)}{0.22} \log P$$

R^{*2} (Based on Parks' method) = 0.99369

R^2 (Based on ordinary least squares) = 0.71698

TABLE 5.6 PRICE AND INCOME ELASTICITIES OF DEMAND BY PARKS' AND ORDINARY LEAST SQUARES METHODS - HOUSEHOLD SUPPLIES AND SOAP AND CLEANING SUPPLIES

	Household Supplies			Soap & Cleaning Supplies	
	Parks'	O.L.S.	Transformed Regression-O.L.S.	Parks'	O.L.S.
Income Elasticity	0.29	.33	0.25	0.66	0.64
Price Elasticity	-2.42	-2.85	-2.29	N.S.	N.S.

Group VI: Drugs and Cosmetics and Newspapers and Magazines

Drugs and Cosmetics

$$\log q = \underset{}{0.92} - \underset{(19.13)}{0.20} \log S_1 - \underset{(21.26)}{0.22} \log S_2 - \underset{(24.25)}{0.32} \log S_3$$

$$1.22 - \underset{(16.74)}{0.20} \log S_1 - \underset{(20.18)}{0.22} \log S_2 - \underset{(24.32)}{0.32} \log S_3$$

$$+ \underset{(8.59)}{0.48} \log y - \underset{(2.54)}{0.48} \log P$$

$$+ \underset{(10.75)}{0.51} \log y - \underset{(3.04)}{0.52} \log P$$

R^{*2} (Based on Parks' method) = 0.99985

R^2 (Based on ordinary least squares) = 0.99944

(continued on page 129)

Newspapers and Magazines

$$\log q = 0.60 - \underset{(53.08)}{0.78} \log S_1 - \underset{(65.03)}{0.89} \log S_2 - \underset{(38.89)}{0.75} \log S_3$$

$$0.78 - \underset{(46.56)}{0.77} \log S_1 - \underset{(60.58)}{0.89} \log S_2 - \underset{(38.13)}{0.76} \log S_3$$

$$+ \underset{(6.21)}{0.54} \log y - \underset{(6.08)}{0.71} \log P$$

$$+ \underset{(7.47)}{0.58} \log y - \underset{(7.08)}{0.73} \log P$$

R^{*2} (Based on Parks' method) = 0.99944

R^2 (Based on ordinary least squares method) = 0.99319

TABLE 5.7 PRICE AND INCOME ELASTICITIES OF DEMAND BY PARKS' AND ORDINARY LEAST SQUARES METHODS - DRUGS AND COSMETICS AND NEWSPAPERS AND MAGAZINES

	Drugs and Cosmetics		Newspapers & Magazines	
	Parks'	O.L.S.	Parks'	O.L.S.
Income Elasticity	0.48	0.51	0.54	0.58
Price Elasticity	-0.48	-0.52	-0.71	-0.73

Group VII: All Food and All Nondurable Goods Excluding Food

All Food

$$\log q = 3.92 - \underset{(16.92}{0.13} \log S_1 - \underset{(7.89)}{0.06} \log S_2 - \underset{(8.72)}{0.07} \log S_3$$

$$3.93 - \underset{(16.64}{0.13} \log S_1 - \underset{(7.74)}{0.06} \log S_2 - \underset{(8.54)}{0.07} \log S_3$$

$$+ \underset{(13.59)}{0.37} \log y - \underset{(6.62)}{0.96} \log P$$

$$+ \underset{(13.11)}{0.37} \log y - \underset{(5.63)}{0.89} \log P$$

R^{*2} (Based on Parks' method) = 0.99999

R^2 (Based on ordinary least squares) = 0.95500

(continued on page 131)

<u>All Nondurable Goods Excluding Food</u>

$$\log q = \underset{}{3.53} - \underset{(16.76)}{0.35} \log S_1 - \underset{(20.67)}{0.37} \log S_2 - \underset{(26.87)}{0.54} \log S_3$$

$$3.57 - \underset{(16.55)}{0.36} \log S_1 - \underset{(20.45)}{0.38} \log S_3 - \underset{(26.38)}{0.54} \log S_3$$

$$+ \underset{(11.81)}{0.92} \log y + \underset{(1.11)}{0.22} \log P$$

$$+ \underset{(10.92)}{0.89} \log y + \underset{(0.3672)}{0.08} \log P$$

R^{*2} (Based on Parks' method) = 0.99997

R^2 (Based on ordinary least squares) = 0.96919

TABLE 5.8 PRICE AND INCOME ELASTICITIES OF DEMAND BY PARKS' AND ORDINARY LEAST SQUARES METHOD - ALL FOOD AND ALL NONDURABLE GOODS EXCLUDING FOOD

	All Food		All Nondurables Excluding Food	
	Parks'	O.L.S.	Parks'	O.L.S.
Income Elasticity	0.37	0.37	0.92	0.89
Price Elasticity	-0.96	-0.89	N.S.	N.S.

The difference between the results based on the transformed regression equation estimated by the ordinary least squares and the results obtained by Parks' method is also great as can be seen from Table 5.2. The results for this commodity group reveal that the results obtained by the two methods are significantly different. We expect the income elasticity and price elasticity to be larger than unity. The results do not support our prior knowledge.[1]

Group II - Tobacco Products and Alcoholic Beverages

The results for this group are presented on page 120. As obtained by the two methods, they are somewhat different. The income elasticity of demand for tabacco products based on Parks' method is only 0.36, while that based on ordinary least squares is 0.58. The price elasticity has the expected sign but is not significant in either of the methods.

The results for alcoholic beverages are approximately the same by both methods except in the case of price elasticity. The income elasticity of demand based on both methods is approximately 0.6. The price elasticity is not significant by Parks' method, while it is -1.1 in the case of ordinary least squares.

Although socially not necessary, both tobacco products

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[1] The possibility that the results do not conform to our prior expectation can be attributed to the data limitations was discussed in Chapter III.

and alcoholic beverages appear to be necessary goods in economic sense as revealed by the result that both the income elasticities of demand are less than unity. These two commodity groups are also not sensitive to price changes. A brief discussion of the implication of this result for economic policy is given in Chapter VI.

Group III - Men's and Women's Clothing

The results for this commodity group are presented on page 118. In the case of men's clothing the results based on both methods are approximately the same except in the case of the price coefficient. The income elasticity of demand is around 0.55, revealing that clothing is a necessary good. The price coefficient is not significant by either of the two methods.

In the case of women's clothing the results by both methods are approximately the same. The income elasticity of demand is around 0.3 while the price elasticity is around 0.6. The former is smaller while the latter is larger than the corresponding coefficient based on the ordinary least squares method.

We find that men's clothing is not significant with respect to price, while women's clothing is significant. This could be due to the fact that men buy clothes largely because it is absolutely necessary for them. Women are more fashion minded. They purchase clothes even if it is not necessary, just to keep up with latest designs or to keep up with changing

fashion. If price goes up women cut down their expenditures because it is now more expensive to keep up with changing fashion. For this reason we find some sensitivity to price change in the demand in the case of women's clothing.

Group IV - Piece Goods and Notions

The results for this group are presented on page 124. The results for piece goods based on the two methods are slightly different. Both results reveal that this commodity group is an inferior good. The results based on both methods have the right sign for price elasticity but are not significant in either of the two methods. The price elasticity is more than six times larger than the price elasticity based on ordinary least squares.

The results for notions are considerably different for the two methods. Both methods reveal that notions are an inferior good. The price elasticity of demand is -2.5 as given by the Parks' method, whereas it is only -1.7 as based on the ordinary least squares method. The difference between the results of the transformed regression equation presented on page 77 and the results based on Parks' method are not considerably different. This shows that the difference in the results can be attributed to serial correlation rather than interrelation in decision making.

As expected both piece goods and notions have turned out to be inferior goods. Each of this category forms about one-half of one per cent of the total nondurable goods consump-

tion. We expect both these commodity groups to reveal inelastic demand with respect to price. Piece goods have an inelastic demand. The commodity group 'notions' has a price elasticity which is much higher (-2.48) than what we expect. This appears to be anomaly in this study.

Group V Household Supplies and Soap and Cleaning Supplies

The results for this commodity group are presented on page 126. The results for household supplies are slightly different for the two methods of estimation. Income elasticity of demand based on Parks' method for household supplies is 0.29 while that based on ordinary least squares is 0.33. The price elasticity of demand is -2.42 based on Parks' method, while it is -2.85 based on ordinary least squares method. Application of an autoregressive transformation alone gave the income elasticity and price elasticity to be 0.25, and -2.29 respectively (page 127). This again shows that the application of Parks' method could result in estimates different from those based on even transformed regression equations. The value of R^2 is quite high by both methods, revealing that the fit is good either way. Nevertheless, we accept the results based on Parks' method rather than those based on ordinary least squares since the rationale behind Parks' method is more appealing than that governing the ordinary least squares method.

The results for soap and cleaning supplies are marginally different by the two methods of estimation. The income elasticity of demand is about .65 by both methods. The price coeffi-

cient is not significant by either method.

The high price elasticity of demand (-2.42) in the case of household supplies can be attributed to the argument developed in the case of women's clothing. As prices go up consumers find it expensive to keep up with fashion. They therefore reduce their expenditures on household supplies if its prices go up. The demand for soap and cleaning supplies was found to be inelastic which could be due to the fact that this category is largely a necessary good in Canadian economy.

Group VI Drugs and Cosmetics and Newspapers and Magazines

The results for this group are presented on page 128. The results for drugs and cosmetics by the two methods are slightly different. The income elasticity of demand by both methods is about one-half. The price elasticity of demand is about minus one-half by both methods. Further, both methods yield a high value for the goodness of fit measure.

The results for newspapers and magazines by the two methods are slightly different. The income elasticity of demand is about 0.54, while the price elasticity of demand is about -0.71. Both these two commodity groups (drugs and cosmetics and, newspapers and magazines) come under the category of necessary goods as supported by our results.

Group VII All Food and All Nondurable Goods Excluding Food

The results for this group are presented on page 130. The results for food are slightly different for the two methods of

estimation. The income elasticity of demand for food is about 0.37. The price elasticity of demand based on Parks' method is -0.96. Food is a necessary good: as expected, the price and income elasticity of demand for food are both less than unity.

The results for the commodity group "All nondurable goods excluding food" are approximately the same by both methods. The income elasticity of demand is 0.92 by Parks' method, while it is 0.89 by the ordinary least squares method. This shows, as expected, that this category is a necessary good. The price coefficient is not significant by either method. The value of R^2 is quite high either way.

An Overview of Empirical Findings

The use of Parks' method gave results which are different from the ordinary least squares method. Part of this difference can be attributed to autocorrelation in the disturbances.

In the case of purchased food, men's clothing, women's clothing, piece goods, soap and cleaning supplies, drugs and cosmetics, newspapers and magazines, and all food and all non-durable goods excluding food, the difference between the ordinary least squares estimates and the estimates based on Parks' method is small. In the case of meals, notions, and household supplies, high serial correlation was found. To overcome this problem, transformed regression equations were estimated in Chapter III. For easy reference the price and income elasticities based on these transformed regression equations are also presented in

Tables 5.2, 5.5, 5.6 respectively for meals, notions, and household supplies. Although the difference between ordinary least squares estimates and the estimates based on Parks' method is great, the difference between the transformed regression coefficients based on ordinary least squares and the estimates based on Parks' methods is not so great in the case of household supplies and notions. In the case of meals this was not true. There was a considerable difference between the results obtained by the transformed regression equation estimated by ordinary least squares and by Parks' method.

The estimates obtained by the two methods are significantly different in the case of tobacco products and alcoholic beverages. In the case of tobacco products, Parks' method gave an income elasticity of demand which is only 0.36, while that based on ordinary least squares was 0.58. In the case of alcoholic beverages, while the income elasticity of demand is approximately the same, the difference in the price elasticity of demand is quite large. While the price coefficient is significant by ordinary least squares method, it is not by Parks' method.

This shows that the estimates could be different by the two different methods. We accept the estimates obtained by Parks' method as it has a better rationale than the ordinary least squares method and our sample size is large.

Part III: Additional Empirical Findings

As mentioned earlier, additional experiments have been

conducted to see the extent of the difference in the elasticities of demand as a result of changes in the pairing adopted in Part II of this chapter. As the interrelation in the demand for piece goods and notions, household supplies and soap and cleaning supplies is clear no additional experiments have been conducted in these cases. Even though the interrelation in the demand for purchased food and meals is strong, one other combination (selected randomly) was tried to see whether the price and income elasticities of demand for purchased food would change significantly. The results of this experiment along with the results of purchased food with meals are presented in Table 5.9. Combining purchased food with drugs and cosmetics did not produce any different results with that of the original combination (purchased food and meals).

Tobacco Products and Alcoholic Beverages

The interrelation of the demand for these two products is not so clear. For this reason these have been tentatively put into one group. Several other combinations have been tried. These are (1) tobacco products with men's clothing, (2) tobacco products with women's clothing, (3) tobacco products with drugs and cosmetics, (4) tobacco products with newspapers and magazines. The results of all these combinations are presented in Table 5.10. It is interesting to note that the price elasticity is not significant in all the five combinations while the income elasticity varied from .33 to .36.

The elasticities of demand for alcoholic beverages with

different combinations are presented in Table 5.11. Here again the price elasticity of demand is not statistically significant with any of the combinations. The range of the income elasticity of demand is .58 to .60.

Men's and Women's Clothing

The interrelation of the demand for these two products is not very clear. For this reason several other combinations have been tried. In the case for men's clothing the results are presented in Table 5.12. The price elasticity of demand is not significant in any of the combinations. The income elasticity of demand is around .56. In short the change in the combination did not change the income elasticity of demand noticeably.

In the case of women's clothing, the results are presented in Table 5.13. The price elasticity of demand for women's clothing showed some variation. The range is -.49 to -.62. The range of income elasticity of demand varied from .30 to .32.

Drugs and Cosmetics and Newspapers and Magazines

Initially these two were included in one group, as these two were left out after the remaining ten commodity groups were paired into five sets. Several other combinations were tried. The results for drugs and cosmetics are presented in Table 5.14, and the results for newspapers and magazines in Table 5.15. In the case of drugs and cosmetics the price elasticity of demand has shown noticeable variation. With newspapers and magazines it gave the lowest price elasticity (-.48). With purchased food it

gave the highest price elasticity (-.68). The income elasticity of demand is around .47 and there was no substantial variation in it.

The results for newspapers and magazines (Table 5.15) also showed noticeable difference in the magnitude of the price elasticity. The range being -.58 to -.72. There was not much variation in the income elasticity of demand.

Summary

In all the combinations tried the value of R^{*2} is quite high. The observed differences in the elasticity of demand for any commodity group with different combinations is due to the fact that the estimated co-variance of the disturbances in different combinations is different. The larger the co-variance, the greater is the interrelation in the demand for the commodity groups in a pair. Only in the case of women's clothing, drugs, and cosmetics, and newspapers and magazines was there noticeable difference in the magnitude of the elasticities of demand. But the confidence intervals of the regression coefficients in these cases have been found to be overlapping.

Part IV: Comparison with Other Studies

In this part of the chapter we compare our estimates with the estimates obtained for the U.K. and the U.S. as well as with the other time series studies conducted for Canada. In particular four studies have been selected for comparison.

TABLE 5.9 ELASTICITIES OF DEMAND - PURCHASED FOOD

	Price Elasticity	Income Elasticity
1. With meals	-1.20 (5.48)	0.498 (13.29)
2. With drugs & cosmetics	-1.22 (7.13)	0.492 (13.47)

TABLE 5.10 ELASTICITIES OF DEMAND - TOBACCO PRODUCTS

	Price Elasticity	Income Elasticity
1. With alcoholic beverages	not significant	0.358 (1.81)
2. With men's clothing	not significant	0.351 (1.78)
3. With women's clothing	not significant	0.333 (1.69)
4. With drugs and cosmetics	not significant	0.334 (1.69)
5. With newspapers and magazines	not significant	0.332 (1.68)

TABLE 5.11 ELASTICITIES OF DEMAND - ALCOHOLIC BEVERAGES

	Price Elasticity	Income Elasticity
1. With tobacco products	not significant	0.580 (8.41)
2. Men's clothing	not significant	0.598 (8.66)
3. Women's clothing	not significant	0.595 (8.57)
4. Drugs and cosmetics	not significant	0.591 (8.58)
5. Newspapers and magazines	not significant	0.577 (8.47)

TABLE 5.12 ELASTICITIES OF DEMAND - MEN'S CLOTHING

	Price Elasticity	Income Elasticity
1. With women's clothing	not significant	0.553 (8.04)
2. With tobacco products	not significant	0.560 (7.97)
3. With alcoholic beverages	not significant	0.561 (8.15)
4. With drugs and cosmetics	not significant	0.561 (7.98)
5. With newspapers and magazines	not significant	0.555 (7.90)

TABLE 5.13 ELASTICITIES OF DEMAND - WOMEN'S CLOTHING

	Price Elasticity	Income Elasticity
1. With men's clothing	-0.608 (5.84)	0.302 (5.90)
2. With tobacco products	-0.604 (4.48)	0.316 (6.26)
3. With alcoholic beverages	-0.491 (4.43)	0.316 (6.15)
4. With drugs and cosmetics	-0.569 (4.32)	0.317 (6.29)
5. With newspapers and magazines	-0.621 (5.25)	0.304 (6.07)

TABLE 5.14 ELASTICITIES OF DEMAND - DRUGS AND COSMETICS

	Price Elasticity	Income Elasticity
1. With newspapers and magazines	-0.483 (2.54)	0.484 (8.59)
2. With tobacco products	-0.628 (3.14)	0.462 (8.09)
3. With alcoholic beverages	-0.580 (2.92)	0.475 (8.35)
4. With men's clothing	-0.515 (2.64)	0.485 (8.59)
5. With women's clothing	-0.577 (2.89)	0.472 (8.30)
6. With purchased food	-0.684 (4.25)	0.456 (8.50)

TABLE 5.15 ELASTICITIES OF DEMAND - NEWSPAPERS & MAGAZINES

	Price Elasticity	Income Elasticity
1. With drugs and cosmetics	-0.715 (6.08)	0.536 (6.21)
2. With tobacco products	-0.673 (5.46)	0.514 (5.84)
3. With alcoholic beverages	-0.581 (5.49)	0.484 (5.89)
4. With men's clothing	-0.579 (5.02)	0.480 (5.64)
5. With women's clothing	-0.583 (5.27)	0.470 (5.63)

I. R. Stone for the U.K.[1]

II. H.S. Houthakker and L.D. Taylor for the U.S.[2]

III. Alan Powell for Canada.[3]

IV. H.S. Houthakker for Canada.[4]

The results giving the comparison of different estimates are presented in Tables 5.16, 5.17, 5.18, and 5.19. The last two studies have been reviewed briefly in Chapter III. A comment on the first two studies is necessary.

The pioneering work of Stone investigates the measurement of demand elasticities for a number of commodities, mostly food, for the U.K. He used both the annual time series data for the period 1920-38 and the budget data for the period 1937-38 to obtain the price and income elasticities of demand for food. The price and income elasticities for tobacco products and alcoholic beverages are obtained on the basis of time series data. The procedure is to estimate individual demand equations separately by ordinary least squares. The explanatory variables in the demand equations are total expenditure, own relative price, prices of substitutes and complementary goods.

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[1] R. Stone and others, The measurement of Consumer's expenditure in the United Kingdom, 1920-1938 (Cambridge University Press, Cambridge 1954).

[2] H.S. Houthakker and L.D. Taylor, <u>op</u>. <u>cit</u>.

[3] A. Powell, <u>op</u>. <u>cit</u>.

[4] H.S. Houthakker, "New Evidence on Demand Elasticities," <u>Econometirica</u>, Vol. 33, No. 2 (April, 1965) pp. 277-288.

In the remainder of this part of the chapter these four studies are referred just by the name of the author.

Houthakker and Taylor's study is one of dynamic demand. The primary purpose of this study is to project the demand for different consumer goods beyond the sample period 1929 - 41 and 1947 - 61. Their model is based on the idea that current purchases depend not only on current income and prices, but also on the pre-existing inventory of the item in question. With additional assumptions they reduce the original model into a distributed lag model. They have used both ordinary least squares method and three-pass least squares method to obtain the reduced form coefficients. In what follows, comments are given on the estimates presented in Tables 5.16 to 5.19

Food

The results giving the comparison of the elasticities of demand for food are given on page 152. Regarding purchased food, our estimates favorably compare with those obtained by the other investigators. Our estimate of the elasticity of demand for purchased food is about one-half. This is also the value found by Stone, and Houthakker and Taylor. It should be noted that Houthakker and Taylor's estimate is an expenditure elasticity which is larger than income elasticity. Our estimate of income elasticity of demand for the category "All food" is smaller than the other estimates. "All food" includes farm foods, purchased foods and meals. Purchased food forms about 41 percent of all nondurable good consumption, while farm foods and meals respectively form only 1.7 and 5.2 percent

of all nondurable good consumption. As the data on farm foods are imputed figures, they are not reliable. For this reason our results for purchased food may be taken as a proxy for "All food". Another justification for this proxy is that purchased food forms 41 percent of all nondurable good consumption.

Our results for purchased food and all food give the price elasticity of demand to be about unity. All other studies have yielded the price elasticity to be in between -0.29 to -0.58. Houthakker and Taylor did not find the price coefficient to be significant at all. Unlike all other studies, our estimates are based on quarterly data which takes into account high seasonal variation. Part of the differences could be attributable to the differences in the specification of the models. It should be noted that completely different sets of results would be obtained in the case of Powell's estimates because he made no adjustment for serial correlation in the disturbances.

Unfortunately, our results for purchased meals do not reveal a significant income coefficient. Our results do not therefore favorably compare with those obtained by Stone and Houthakker and Taylor. The price elasticity of demand in our study (-0.69) is also much smaller than the one obtained by Houthakker and Taylor for the United States which is -2.3.

Tobacco Products and Alcoholic Beverages

The results giving the comparison of our estimates with the estimates obtained by other investigators are presented on page 153. Our estimates for tobacco products lie between the estimates obtained by Stone for the United Kingdom and the others obtained by Houthakker and Taylor for the United States. It should be noted that the elasticities obtained by Houthakker and Taylor for the United States are expenditure elasticities and not income elasticities.[1]

Separate estimates for the group "Alcoholic Beverages" are not presented in Stone's study. In his study Stone presents results for four types of drinks, viz., beer, spirits, imported wine, and British wine. There is a good deal of difference in the income elasticities between these four categories of drinks. The income elasticity of demand for the aggregate commodity group "Drink and Tobacco" is only 0.20. We can compare the results of Stone's commodity group "Drink and Tobacco" with the average of our groups "Tobacco Products" and "Alcohol Beverages". These, respectively, form 5.56 and 7.74 percent of the total expenditure on nondurable good consumption. Comparing the average of the income elasticity of demand of our estimates with Stone's estimate for drink and tobacco and Houthakker and Taylor's average income elasticity of demand for ("Tobacco Products" and

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[1] It should be noted that income elasticities are in general smaller than expenditure elasticities.

"Alcoholic Beverages") these commodities, we find that our estimate is larger than that obtained for the U.K. and the U.S.[1]

The price coefficient was significant in Stone's study, while in Houthakker and Taylor's study it was not. The price coefficients in our study of tobacco products and alcoholic beverages are not significant.

Powell's estimates for Canada revealed positive and significant serial correlation in the disturbances. Had the transformation been done by Powell the results could have been different. As it is his estimate of the income elasticity of demand is larger than the average income elasticity of demand in our study.

Clothing

The results giving the comparison of our estimates for clothing with others are presented on page 154. Houthakker and Taylor's study gives long-run expenditure elasticity of demand to be 0.66. This is larger than our estimates. When adjustment is made to their estimates to obtain income elasticity, their estimate is very close to our estimate of income elasticity of demand for men's clothing. While prices play no

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[1] Houthakker and Taylor's estimates are expenditure elasticities. We might multiply by a factor 9/10 to obtain income elasticities. This factor 9/10 has been frequently used by Stone in his study. The above mentioned statement is not true if we compare Houthakker and Taylor's average of long-run expenditure elasticities for tobacco products and alcoholic beverages (1.15 and 0.53) with our estimates.

role in their study, they are statistically significant in our study in the case of women's clothing and notions. Surprisingly, Houthakker's estimates for Canada give a negative expenditure elasticity and a low price elasticity for clothing. Powell's estimates of income and price elasticities are larger than our estimates. Again, his estimates reveal positive serial correlation in the disturbances.

Newspapers and Magazines

The results for this commodity group giving the comparison of elasticities are presented on page 155. The expenditure elasticity obtained by Houthakker and Taylor and our estimate of income elasticity are in agreement. But there is a considerable difference in the price elasticity of demand in these two studies. This difference could in part be due to the different types of models adopted.[1]

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[1] Our results very favorably compare with Houthakker and Taylor's static model, which reveals the expenditure coefficient to be 0.005 and the price coefficient to be -0.0244. The corresponding coefficients in our study based on simple linear form are, respectively, 0.0067 and -0.0221. Both Houthakker and Taylor's study and our results yield a high value for the coefficient of multple determination. For their results see H.S. Houthakker and L.D. Taylor *op. cit.*, p. 127.

TABLE 5.16 A COMPARISON OF ELASTICITES OF DEMAND FOR FOOD IN U.S., U.K. AND CANADA

Investigator/Country/Period Commodity Group	Income Elasticity	Price Elasticity
I. R. Stone, U.K.		
a. All food (1920-38)	0.53	-0.58
b. Meals away from home Budget data (1937-39)	2.39	not estimated
II. H.S. Houthakker and L.D. Taylor United States (1929-41, 1947-61)		
a. Food purchased for off-premise consumption (excluding Alcoholic beverages)	0.56 expenditure elast.	N.S.
b. Purchased meals	1.52 expenditure elast.	-2.30
III. A. Powell, Canada (1949-63)		
a. All food	0.58	-0.46
IV. H.S. Houthakker, Canada (1948-59)		
a. All food	0.69 expenditure elast.	-0.29
V. Ours (1956-65)		
a. Purchased food Parks' method	0.50	-1.20
b. Meals Parks' method	N.S.	-0.69
c. All food Parks' method	0.37	-0.96

TABLE 5.17 A COMPARISON OF ELASTICITIES OF DEMAND FOR TOBACCO PRODUCTS AND ALCOHOLIC BEVERAGES IN U.S., U.K. AND CANADA

Investigator /Country/Period Commodity Group	Income Elasticity	Price Elasticity
I. R. Stone - U.K.		
a. Tobacco as a whole (1920-38)	0.25	-0.27
b. Beer (1920-38)	-0.05 not significant	-0.87
c. Spirits (1920-38)	0.60	-0.57
d. Imported wine (1920-38)	1.40	-0.60
e. British wine (1927-38)	1.70	-0.31
f. Drink and Tobacco (1920-38)	0.20	-0.74
II. Houthakker and Taylor - U.S.A.		
a. Tobacco Products (1929-41, 1947-61)	0.59 expenditure elast.	not included
b. Alcoholic Beverages (1929-41, 1947-61)	0.24 expenditure elast.	not included
III. Alan Powell - Canada		
a. Tobacco and Alcohol (1949-63)	0.79	-0.54
IV. Ours (1956-65)		
a. Tobacco Products Parks' method	0.36	N.S.
b. Alcoholic beverages Parks' method	0.58	

TABLE 5.18 A COMPARISON OF ELASTICITIES OF DEMAND - CLOTHING

Investigator/ Country/Period Commodity Group		Income Elasticity	Price Elasticity
I. H.S. Houthakker and L.D. Taylor U.S.A. (1929-41, 1947-61)		0.54 Long-run expenditure elast.	
a. Clothing including luggage		.97 Short-run expenditure elast.	not included
II. H.S. Houthakker, Canada (1948-59)		-0.09	-0.38
a. Clothing		expenditure elast.	
III. A. Powell, Canada (1949-63)			
a. Clothing		0.74	-0.52
IV. Ours, (1956-65)			
a. Men's clothing	Parks' Method	0.55	N.S.
b. Women's clothing	Parks' Method	0.30	-0.49 to -0.62
c. Piece goods	Parks' Method	-0.32	N.S.
d. Notions		-0.86	-2.48

TABLE 5.19 A COMPARISON OF ELASTICITIES OF DEMAND - NEWSPAPERS AND MAGAZINES

Investigator/Country/Period	Income Elasticity	Price Elasticity
I. Houthakker and Taylor U.S.A. (1929-41, 1947-61)	.52 expenditure elast.	-0.11
II. Ours (1956-65) Parks' method	0.54	-0.71

CHAPTER VI

CONCLUSIONS

The following conclusions can be drawn from this study.

1. It is found that the demand for tobacco products and alcoholic beverages is perfectly inelastic with respect to price. All the empirical evidence in this study suggests that the demand for tobacco products and alcoholic beverages is perfectly inelastic with respect to price. It should also be noted that we have taken 5 per cent level of significance as the criterion. This is an arbitrarily chosen level of significance. But this level of significance is widely used in econometric studies. If we take different levels of significance we get different conclusions. Also the conclusions using Bayesian Methods would be different. Our results point out that the demand for tobacco products and alcoholic beverages is inelastic. What are its policy implications? H.E. English has pointed out that, in Canada, tobacco products and alcoholic beverages are not accepted as socially necessary.[1] This suggests that government could increase tax revenue by imposing excise tax on these products. Our results show that imposition of excise tax

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[1] T.N. Brewis, H.E. English, Anthony Scott, Pauline Jewett with a statistical Appendix by J.E. Gander, Canadian Economic Policy, Revised Edition (The Macmillan Company of Canada Limited, Toronto, 1965), p. 8.

on these products will not curtail the demand. In this extreme case of perfectly inelastic demand the incidence of the tax falls entirely on consumers. As drugs and cosmetics have a price elasticity of -.48 to -.68 similar policy statement can be made about the cosmetics part of the commodity group "Drugs and cosmetics". This assumes that cosmetics are socially not necessary. Even though some of the other commodities like food, clothing, soap and cleaning supplies and newspapers and magazines have an inelastic demand taxing such commodities is not desirable. Such taxes may be politically unpopular.

2. Our results show that prices play a more modest role than real disposable income in the demand for nondurable goods in the Canadian economy.[1] This may be due to a high level of income in the Canadian economy. That prices play a more modest role than total expenditures was also found in the consumer demand study for the United States.[2]

3. As expected, the expenditure elasticity of demand is always larger than the income elasticity of demand. As

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[1] In our study the insignificant price coefficients in certain commodity groups do not appear to be due to multicollinearity. This is supported by the fact that the correlation between relative prices and real income is not high. It is in general less than 0.5. For example, in the case of soap and cleaning supplies where the price coefficient is not significant, the correlation coefficient between relative price and real disposable income is only 0.1. It should be noted that the problem of multicollinearity would be serious if we take absolute prices and income as explanatory variables.

[2] H.S. Houthakker and L.D. Taylor, op. cit., p. 195.

income increases, a greater percentage of income will be saved, so the proportionate change in total expenditure will be less than the proportionate change in total income.

4. The lag in the consumer response to changes in relative prices and real income, in the demand for nondurable goods, is statistically significant. But the size of the lag is small. This study suggests that about 4 to 5 months time is enough for consumers to adjust their expenditures on different commodity groups to changes in relative prices and real disposable income.

5. In the context of the distributed lag model, application of Liviatan's Method[1] gave results which are very much different from those obtained by the ordinary least squares method. The implied time shape of reaction is also very much different between the two methods. The results given by the ordinary least squares method tend to overestimate the implied lag in consumer behaviour.

6. In the case of meals, household supplies, and notions high serial correlation is found. An autoregressive transformation is adopted. The transformed regression equation estimates are significantly different from those without transformation.

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[1] N. Liviatan, op. cit.

7. Application of Parks' method[1] gave results different from those obtained by ordinary least squares. Part of this difference can be attributed to serial correlation in the disturbances and part to the interrelation in the demand for different goods. There is evidence to show that serial correlation is more important problem than the interrelation in the demand.

Conclusions 5, 6, and 7 suggest that improved statistical techniques could lead us to revise our conclusions based on estimates obtained by the traditional techniques. For example, whereas Parks' method gave insignificant price coefficient for the commodity group alcoholic beverages, ordinary least squares method gave a significant price coefficient.

8. In the case of some nondurable goods it is found that price coefficients are statistically significant. When we estimate the aggregate categories, "All nondurable goods" and "All nondurable goods excluding food", we found that prices are not significant. Aggregation, therefore, resulted in loss of some relevant information.[2]

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[1] R.W. Parks, op. cit.

[2] From this result alone we cannot draw a sweeping conclusion that aggregation is bad. For two different views on this topic of aggregation see H. Theil, Linear Aggregation of Economic Relations (Amsterdam: North Holland, 1954) and Y. Grunfeld, and Zvi Griliches, "Is Aggregation Necessarily Bad", Review of Economics and Statistics, Vol. 32 (1960), pp. 1-14.

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APPENDIX I - AN APL PROGRAM FOR PARKS' METHOD

```
       ∇REDDY[⎕]∇
     ∇ R←REDDY
[1]    T←(⍴DATA1)[1]
[2]    K←¯1+(⍴DATA1)[2]
[3]    U1←(((⍳K+1)REG DATA1)RES DATA1)[;4]
[4]    U2←(((⍳K+1)REG DATA2)RES DATA2)[;4]
[5]    M←(2,T)⍴U1,U2
[6]    S←(T-K)×INV M+.×⍉M
[7]    X1←⍉((K+1),T)⍴(T⍴1),,⍉DATA1[;⍳K]
[8]    Y1←DATA1[;K+1]
[9]    X2←⍉((K+1),T)⍴(T⍴1),,⍉DATA2[;⍳K]
[10]   Y2←DATA2[;K+1]
[11]   Q←((2×K+1),2×K+1)⍴0
[12]   Q[⍳K+1;⍳K+1]←S[1;1]×(⍉X1)+.×X1
[13]   Q[⍳K+1;K+1+⍳K+1]←S[1;2]×(⍉X1)+.×X2
[14]   Q[K+1+⍳K+1;⍳K+1]←S[2;1]×(⍉X2)+.×X1
[15]   Q[K+1+⍳K+1;K+1+⍳K+1]←S[2;2]×(⍉X2)+.×X2
[16]   E←(S[1;1]×(⍉X1)+.×Y1)+S[1;2]×(⍉X1)+.×Y2
[17]   F←(S[2;1]×(⍉X2)+.×Y1)+S[2;2]×(⍉X2)+.×Y2
[18]   RESULT←((2×K+1),5)⍴0
[19]   RESULT[;1]←R←(VAR←INV Q)+.×E,F
[20]   RESULT[;4]←R÷RESULT[;3]←(RESULT[;2]←(1 1)⍉VAR)*0.5
[21]   RESULT[1;5]←(R[⍳K+1]+.×(⍉X1)+.×Y1)÷Y1+.×Y1
[22]   RESULT[K+2;5]←(R[K+1+⍳K+1]+.×(⍉X2)+.×Y2)÷Y2+.×Y2
     ∇
       ∇CONVERT[⎕]∇
     ∇ RX←R CONVERT X
[1]    RX←(1↓X)-R×¯1↓X
     ∇
```

APPENDIX II

THE DATA

The data used are presented in this appendix. The data were supplied by Mr. A.S. Foti, Chief, National Accounts Section, Dominion Bureau of Statistics, Ottawa. The data have several limitations. They are not seasonally adjusted. Some of the series do not adequately measure what their titles suggest.

TABLE A.1

PERSONAL EXPENDITURE ON CONSUMER GOODS AND SERVICES MILLIONS OF CONSTANT (1957) DOLLARS.

	I	II	III	IV
1956	4460.	4896.	4787.	5335.
1957	4629.	5023.	4959.	5461.
1958	4790.	5123.	5098.	5696.
1959	5029.	5407.	5344.	5931.
1960	5182.	5605.	5497.	6118.
1961	5307.	5769.	5702.	6327.
1962	5687.	6058.	5836.	6592.
1963	5889.	6307.	6120.	6944.
1964	6302.	6678.	6511.	7355.
1965	6564.	7111.	6896.	7891.

TABLE A.2

PERSONAL DISPOSABLE INCOME (PERSONAL INCOME LESS PERSONAL DIRECT TAXES) MILLIONS OF DOLLARS.

	I	II	III	IV
1956	4330.	4755.	6017.	5051.
1957	4801.	5133.	6013.	5327.
1958	5184.	5592.	6397.	5741.
1959	5528.	5972.	6760.	5976.
1960	5812.	6035.	7025.	6212.
1961	6071.	6292.	7023.	6625.
1962	6459.	6874.	7896.	7014.
1963	6737.	7272.	8498.	7511.
1964	7400.	7571.	8732.	8022.
1965	8084.	8214.	9749.	8943.

TABLE A.3

CONSUMER PRICE INDEX OF ALL GOODS AND SERVICES (1957 = 100).

	I	II	III	IV
1956	95.10	95.61	96.99	98.48
1957	98.96	99.96	100.5	100.5
1958	101.6	103.0	102.7	103.0
1959	103.8	103.9	104.0	104.5
1960	104.6	105.0	105.1	105.4
1961	105.8	105.8	106.1	105.9
1962	106.4	107.0	107.8	107.6
1963	108.0	108.4	109.6	109.2
1964	109.6	110.1	111.3	110.9
1965	111.4	112.2	113.5	113.4

TABLE A.4

POPULATION OF CANADA (MILLIONS OF PERSONS).

	I	II	III	IV
1956	15.99	16.08	16.21	16.35
1957	16.48	16.61	16.73	16.84
1958	16.96	17.08	17.18	17.28
1959	17.38	17.48	17.58	17.68
1960	17.77	17.87	17.96	18.05
1961	18.15	18.24	18.32	18.40
1962	18.49	18.57	18.65	18.73
1963	18.81	18.90	18.98	19.07
1964	19.15	19.23	19.32	19.40
1965	19.49	19.57	19.65	19.74

TABLE A.5

CONSUMER EXPENDITRUE ON FARM FOODS, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	34.40	17.00	40.70	75.40
1957	36.60	15.90	40.90	76.80
1958	35.60	15.90	41.80	80.80
1959	35.80	15.50	40.00	75.10
1960	36.90	15.30	40.30	76.20
1961	30.80	13.00	37.10	75.30
1962	29.90	12.40	36.50	69.10
1963	29.00	12.10	37.10	69.70
1964	28.60	11.90	38.00	69.70
1965	27.80	11.40	36.70	70.70

TABLE A.6

PRICE INDEX FOR FARM FOODS (1957 = 100).

	I	II	III	IV
1956	98.5	105.8	104.6	99.90
1957	101.7	96.80	100.0	96.50
1958	104.0	103.9	101.0	95.70
1959	106.5	103.3	101.3	101.1
1960	97.50	102.0	105.0	104.3
1961	110.7	107.7	104.3	93.60
1962	109.4	100.8	106.6	105.1
1963	115.5	108.3	108.6	104.4
1964	108.7	100.0	107.1	106.9
1965	109.4	107.0	116.3	121.1

TABLE A.7

CONSUMER EXPENDITURE ON PURCHASED FOODS, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	933.4	1061.	1064.	1022.
1957	984.7	1077.	1098.	1106.
1958	1025.	1097.	1128.	1133.
1959	1058.	1173.	1195.	1195.
1960	1126.	1222.	1255.	1238.
1961	1125.	1261.	1275.	1256.
1962	1195.	1285.	1289.	1297.
1963	1208.	1317.	1315.	1330.
1964	1255.	1343.	1359.	1394.
1965	1274.	1389.	1402.	1446.

TABLE A.8

PRICE INDEX FOR PURCHASED FOODS (1957 = 100).

	I	II	III	IV
1956	92.9	93.20	97.20	99.20
1957	99.70	100.2	101.6	99.50
1958	101.9	105.7	104.1	102.8
1959	103.4	102.4	102.7	103.0
1960	102.3	102.9	103.5	104.2
1961	104.6	103.9	104.8	104.1
1962	105.0	105.5	107.4	107.4
1963	108.2	107.9	111.2	109.6
1964	110.2	110.4	112.7	110.5
1965	111.2	113.3	115.5	115.4

TABLE A.9

CONSUMER EXPENDITURE ON MEALS, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	118.8	133.8	140.5	127.2
1957	122.5	135.1	143.2	132.2
1958	115.6	124.6	135.4	127.3
1959	116.1	132.2	144.2	132.9
1960	122.1	132.4	142.4	127.8
1961	116.9	129.2	141.6	130.5
1962	124.4	135.7	149.2	134.6
1963	127.3	138.8	150.9	137.8
1964	131.4	137.2	154.9	143.2
1965	132.7	142.9	160.7	147.4

TABLE A.10

PRICE INDEX FOR MEALS (1957 = 100).

	I	II	III	IV
1956	92.9	93.20	97.20	99.20
1957	98.80	100.2	101.6	99.50
1958	101.9	105.7	104.1	102.8
1959	103.4	102.4	102.7	103.0
1960	102.3	102.9	103.5	104.2
1961	104.6	103.9	104.8	104.1
1962	105.0	105.5	107.4	107.4
1963	108.2	107.9	111.2	109.6
1964	110.2	110.4	112.7	110.5
1965	111.2	113.3	115.5	115.4

TABLE A.11

CONSUMER EXPENDITURE ON TOBACCO PRODUCTS,
MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	115.0	121.9	130.1	160.3
1957	118.2	132.7	148.1	171.4
1958	135.0	147.3	152.8	179.9
1959	142.5	155.5	155.4	190.1
1960	142.3	154.3	161.8	190.4
1961	152.6	178.8	175.0	176.2
1962	162.6	189.1	180.7	184.2
1963	166.3	193.5	183.7	185.9
1964	153.2	191.6	196.3	195.0
1965	173.8	202.0	200.2	197.9

TABLE A.12

PRICE INDEX FOR TOBACCO PRODUCTS (1957 = 100).

	I	II	III	IV
1956	100.0	100.0	100.0	100.0
1957	100.0	100.0	100.0	100.0
1958	100.0	100.0	100.0	100.3
1959	100.7	105.9	108.4	108.4
1960	108.4	108.2	108.1	108.3
1961	108.3	108.4	109.1	110.0
1962	109.8	109.6	109.7	109.4
1963	109.5	109.6	110.2	109.6
1964	109.7	109.9	110.2	112.6
1965	112.8	113.9	114.4	114.2

TABLE A.13

CONSUMER EXPENDITURE ON ALCOHOLIC BEVERAGES, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	150.2	174.1	195.8	249.8
1957	152.5	193.4	213.7	238.9
1958	153.6	197.2	209.1	251.8
1959	159.3	204.3	225.5	252.5
1960	166.0	211.7	228.6	258.3
1961	170.8	215.6	240.1	264.6
1962	178.7	231.9	239.9	279.2
1963	186.2	233.0	256.2	290.5
1964	204.1	236.3	261.8	292.4
1965	202.8	261.0	282.6	330.7

TABLE A.14

CONSUMER PRICE INDEX FOR ALCOHOLIC BEVERAGES.

	I	II	III	IV
1956	97.20	97.20	97.20	98.00
1957	98.80	99.90	100.3	101.0
1958	101.5	101.7	101.7	101.7
1959	101.8	102.3	103.6	104.4
1960	104.4	104.4	104.6	104.6
1961	104.6	104.8	105.4	106.2
1962	106.4	107.3	107.4	107.4
1963	107.4	107.4	107.4	108.1
1964	109.2	110.3	110.6	110.7
1965	111.0	111.2	111.2	111.3

TABLE A.15

CONSUMER EXPENDITURE ON MEN'S CLOTHING, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	91.10	109.5	97.50	173.1
1957	90.30	113.2	99.50	166.9
1958	94.00	111.5	100.0	172.1
1959	96.40	115.1	103.4	177.7
1960	95.80	123.9	109.9	182.7
1961	99.20	122.1	112.7	182.3
1962	105.1	129.1	117.9	189.2
1963	106.6	135.5	123.3	197.9
1964	113.7	136.9	132.6	210.5
1965	116.3	146.9	140.9	221.7

TABLE A.16

PRICE INDEX FOR MEN'S CLOTHING (1957 = 100).

	I	II	III	IV
1956	98.1	98.20	98.30	98.40
1957	99.20	100.1	100.2	100.7
1958	100.0	100.7	101.0	101.4
1959	101.1	101.2	101.4	101.8
1960	101.2	101.3	101.4	102.6
1961	102.5	102.7	103.0	104.2
1962	102.8	104.6	104.3	106.2
1963	105.9	106.9	106.9	108.0
1964	108.2	108.8	109.0	109.9
1965	108.9	111.1	111.0	112.5

TABLE A.17

CONSUMER EXPENDITURE ON WOMEN'S CLOTHING, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	163.6	209.1	190.9	287.3
1957	171.0	227.6	203.2	294.0
1958	179.8	220.9	207.5	311.0
1959	189.1	234.5	217.3	325.2
1960	188.0	247.6	227.1	335.0
1961	202.8	245.0	233.2	335.6
1962	204.2	264.6	243.3	341.8
1963	204.0	264.7	250.4	344.3
1964	216.3	261.9	258.1	359.8
1965	215.1	280.6	273.9	382.1

TABLE A.18

PRICE INDEX FOR WOMEN'S CLOTHING (1957 = 100).

	I	II	III	IV
1956	103.0	103.0	102.1	101.7
1957	99.60	100.0	99.40	101.4
1958	100.6	101.7	101.1	102.0
1959	99.60	100.1	99.20	101.0
1960	99.20	99.90	99.20	101.0
1961	99.70	101.2	101.0	102.0
1962	99.90	100.3	99.80	104.5
1963	102.7	103.7	103.5	108.8
1964	107.0	108.0	107.9	110.7
1964	107.8	108.6	108.2	112.0

TABLE A.19

CONSUMER EXPENDITURE ON PIECE-GOODS, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	22.20	18.10	16.50	20.30
1957	23.50	17.70	16.70	19.50
1958	24.60	18.80	17.50	19.10
1959	25.90	17.90	17.20	19.90
1960	26.40	18.40	18.30	20.70
1961	27.20	19.40	18.90	20.60
1962	26.60	18.40	17.70	19.10
1963	25.50	19.60	19.40	21.40
1964	26.80	20.50	19.60	21.00
1965	25.20	19.30	19.80	20.90

TABLE A.20

PRICE INDEX FOR PIECE-GOODS (1957 = 100).

	I	II	III	IV
1956	97.50	97.50	97.90	98.30
1957	98.70	100.6	100.7	100.0
1958	99.10	99.40	99.60	100.3
1959	100.2	99.70	99.90	100.5
1960	100.5	101.2	100.6	101.4
1961	101.6	101.8	101.7	102.8
1962	103.1	104.9	106.6	107.8
1963	108.5	108.6	108.1	108.5
1964	108.4	108.2	110.1	110.3
1965	110.1	110.9	111.2	111.0

TABLE A.21

CONSUMER EXPENDITURE ON NOTIONS, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	12.40	12.20	11.30	17.40
1957	12.60	12.00	12.00	18.00
1958	13.30	13.00	13.30	19.70
1959	14.20	12.90	13.20	20.20
1960	14.40	13.50	13.30	20.00
1961	13.20	13.00	12.70	18.50
1962	13.00	11.80	12.10	17.20
1963	11.60	11.40	12.40	17.30
1964	12.10	11.70	12.00	17.20
1965	11.90	11.40	12.80	17.50

TABLE A.22

PRICE INDEX FOR NOTIONS (1957 = 100).

	I	II	III	IV
1956	97.50	97.50	97.90	98.30
1957	98.70	100.6	100.7	100.0
1958	99.10	99.40	99.60	100.3
1959	100.2	99.70	99.90	100.5
1960	100.5	101.2	100.6	101.4
1961	101.6	101.6	101.7	102.8
1962	103.1	104.9	106.6	107.8
1963	108.5	108.6	108.1	108.5
1964	108.4	108.2	110.1	110.3
1965	110.1	110.9	111.2	111.0

TABLE A.23

CONSUMER EXPENDITURE ON FOOTWEAR, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	45.6	66.60	58.10	76.20
1957	45.70	69.50	60.90	76.20
1958	49.50	70.90	63.70	82.00
1959	49.80	74.00	64.80	83.20
1960	49.00	78.50	66.90	86.10
1961	51.00	74.20	67.20	83.90
1962	51.60	77.30	68.70	89.70
1963	50.80	77.50	68.90	90.40
1964	53.30	75.20	70.60	93.50
1965	50.90	77.40	72.30	95.70

TABLE A.24

PRICE INDEX FOR FOOTWEAR (1957 = 100).

	I	II	III	IV
1956	97.5	97.90	98.40	99.10
1957	99.30	100.0	100.2	100.4
1958	101.0	101.3	101.3	101.3
1959	101.9	102.7	105.4	107.2
1960	107.9	109.4	109.2	110.6
1961	111.8	111.8	112.3	113.2
1962	113.0	113.5	113.7	114.1
1963	114.6	114.4	114.8	114.9
1964	115.5	116.1	116.1	117.0
1965	118.7	120.2	120.3	122.3

TABLE A.25

CONSUMER EXPENDITURE ON HOUSEHOLD SUPPLIES, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	19.4	30.10	31.30	33.40
1957	20.10	30.50	30.90	32.80
1958	20.40	31.40	31.40	34.20
1959	20.70	31.90	31.50	34.30
1960	20.40	30.20	30.80	33.80
1961	19.90	30.60	31.10	32.60
1962	19.50	30.10	29.70	32.30
1963	19.30	30.10	30.30	33.00
1964	21.30	31.10	31.80	34.50
1965	21.50	32.70	33.80	37.20

TABLE A.26

PRICE INDEX FOR HOUSEHOLD SUPPLIES (1957 = 100).

	I	II	III	IV
1956	95.2	95.70	96.40	97.70
1957	98.50	99.90	100.5	101.0
1958	102.0	102.5	102.7	102.9
1959	103.4	103.6	104.6	105.2
1960	106.0	107.4	107.8	107.8
1961	107.8	108.0	108.6	109.7
1962	110.2	111.0	112.4	115.1
1963	115.9	115.5	115.5	116.3
1964	116.5	116.5	116.5	116.7
1965	117.0	117.9	118.8	119.5

TABLE A.27

CONSUMER EXPENDITURE ON SOAP AND CLEANING SUPPLIES, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	18.9	21.20	20.30	20.10
1957	21.40	21.50	21.20	22.00
1958	22.00	23.50	23.40	22.50
1959	22.30	23.00	24.10	21.80
1960	23.10	24.20	25.00	21.70
1961	24.00	25.20	24.40	22.80
1962	25.50	27.10	25.20	26.00
1963	25.90	27.60	25.60	26.50
1964	27.00	28.90	26.70	27.40
1965	27.50	30.20	29.80	28.60

TABLE A.28

PRICE INDEX FOR SOAP AND CLEANING SUPPLIES (1957 = 100).

	I	II	III	IV
1956	97.9	98.00	98.30	98.90
1957	98.80	99.70	100.2	101.5
1958	101.1	101.7	101.9	103.8
1959	104.7	105.1	106.2	106.8
1960	107.1	107.5	108.2	108.0
1961	108.3	108.0	108.8	109.4
1962	109.7	109.8	109.9	110.2
1963	111.0	110.9	110.6	110.3
1964	111.5	111.4	112.0	112.1
1965	113.3	114.3	114.9	115.2

TABLE A.29

CONSUMER EXPENDITURE ON DRUGS AND COSMETICS, MILLIONS OF 1957 DOLLARS.

	I	II	II	IV
1956	80.70	82.30	82.80	97.90
1957	83.60	86.90	87.00	104.1
1958	88.30	90.30	88.90	104.6
1959	91.30	92.00	91.00	107.0
1960	92.40	92.10	92.20	111.0
1961	96.20	99.30	98.40	114.1
1962	101.7	99.30	101.2	120.3
1963	104.6	105.1	105.3	124.0
1964	107.4	107.7	110.6	130.8
1965	110.9	113.0	115.9	139.8

TABLE A.30

PRICE INDEX FOR DRUGS AND COSMETICS (1957 = 100).

	I	II	III	IV
1956	96.60	96.70	96.90	97.40
1957	98.60	99.50	100.7	101.2
1958	102.8	103.7	104.5	105.1
1959	105.9	106.9	108.5	109.1
1960	109.7	109.7	109.6	107.7
1961	106.9	106.3	106.7	107.4
1962	107.0	107.2	107.1	106.7
1963	106.6	107.3	107.8	108.3
1964	108.2	108.3	108.4	109.7
1965	110.4	111.1	111.4	112.2

TABLE A.31

CONSUMER EXPENDITURE ON NEWSPAPERS AND MAGAZINES, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	39.90	36.60	42.30	69.60
1957	40.10	38.50	45.70	71.10
1958	38.40	36.40	43.40	67.50
1959	38.60	36.00	43.30	70.10
1960	39.30	37.50	44.80	71.30
1961	42.40	39.40	47.10	75.10
1962	42.70	41.20	48.70	74.70
1963	42.70	40.60	50.40	77.20
1964	44.80	43.00	51.40	82.60
1965	46.40	45.00	53.80	86.30

TABLE A.32

PRICE INDEX FOR NEWSPAPERS AND MAGAZINES (1957 = 100).

	I	II	III	IV
1956	98.40	97.20	97.60	98.00
1957	98.00	98.80	101.4	102.0
1958	113.0	113.0	114.3	115.7
1959	117.1	117.1	116.9	116.2
1960	117.0	117.0	117.9	118.3
1961	118.8	118.9	118.8	118.6
1962	120.0	120.8	123.0	123.0
1963	123.1	123.1	123.1	125.2
1964	129.0	127.5	129.2	129.0
1965	132.5	132.5	133.5	133.3

TABLE A.33

CONSUMER EXPENDITURE ON ALL NONDURABLE GOODS, MILLIONS OF 1957 DOLLARS.

	I	II	III	IV
1956	2249.	2390.	2453.	2904.
1957	2333.	2503.	2555.	3011.
1958	2425.	2532.	2595.	3090.
1959	2508.	2643.	2722.	3218.
1960	2593.	2763.	2821.	3283.
1961	2636.	2835.	2892.	3360.
1962	2851.	2959.	3029.	3493.
1963	2924.	3021.	3120.	3576.
1964	3032.	3144.	3255.	3803.
1965	3146.	3314.	3436.	4017.

TABLE A.34

CONSUMER EXPENDITURE ON ALL NONDURABLE GOODS, MILLIONS OF CURRENT DOLLARS.

	I	II	III	IV
1956	2158.	2296.	2404.	3013.
1957	2312.	2504.	2573.	3147.
1958	2457.	2615.	2659.	3147.
1959	2565.	2703.	2790.	3315.
1960	2653.	2842.	2913.	3405.
1961	2734.	2937.	3016.	3491.
1962	2966.	3098.	3203.	3698.
1963	3091.	3212.	3367.	3848.
1964	3259.	3408.	3578.	4144.
1965	3417.	3663.	3847.	4507.